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The Stereoscope and Stereoscopic Photography

by F. Drouin

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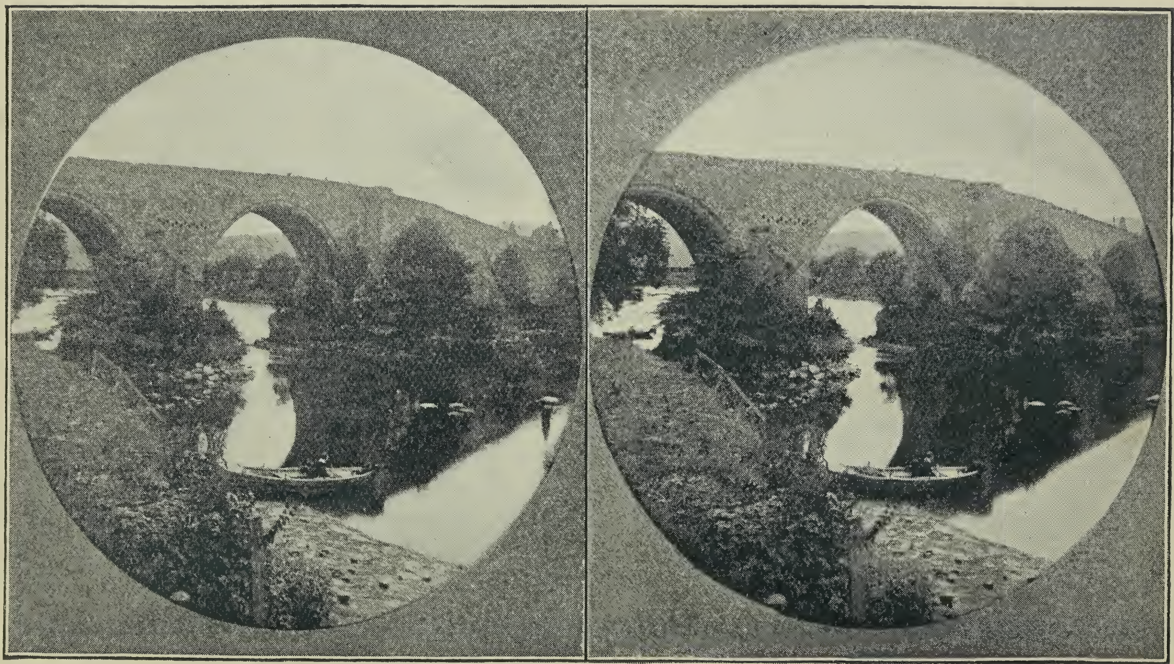

Photograph by Andrew Young.

STEREOGRAPH

Effect of looking through window produced by masking.

THE

STEREOSCOPE

AND

STEREOSCOPIC PHOTOGRAPHY.

From the French of F. Drouin.

TRANSLATED BY MATTHEW SURFACE,
EDITOR OF *The Practical Photographer.*

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TRANSLATOR'S PREFACE.

NO book dealing with the theory and practice of the stereoscope and stereoscopic photography has been published in this country since about 1860, when Sir David Brewster gave to the world his now historic work. The active revival of stereoscopy brings with it the need of a modern treatise on the subject, more adapted to the times than the book of thirty years ago; for if in optical knowledge but few strides have been made, in matters photographic our progress has been enormous. The present work is almost a literal translation from "Le Stéréoscope et la Photographie Stéréoscopique" of M. Drouin, only a few alterations and interpolations having been made in the necessary anglification. The metric system was adopted by the author, and it has been deemed advisable in most instances not to convert into the cruder English method.

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THE STEREOSCOPE

AND

STEREOSCOPIC PHOTOGRAPHY.

BINOCULAR VISION THE PERCEPTION OF RELIEF.

WHEN we are looking at a flat picture, such as a drawing or a photograph, we grasp, without difficulty, the form and relative proportion of the objects which compose it, and we are equally able to form an idea of the distances of these objects, in the direction perpendicular to the picture. Yet, the impression received is very incomplete when compared with that given by a view of the object itself. However perfect the drawing, the picture always appears flat; the relief is wanting. If two objects, the dimensions of which are not already known, are represented in a picture, without being accompanied by something which might give an idea of their respective

positions, it is often difficult to tell which of them is nearer, and which further away.

The same impression is received when looking at the objects themselves, *with one eye*, which suggests the idea that the sight of both eyes is indispensable to the complete perception of relief. The accuracy of this long-established opinion has been confirmed by the discovery of the *stereoscope*, an apparatus which, with the aid of two pictures of the same thing, gives precisely the impression of relief, which would be produced by looking at the thing itself.

We must state at the outset, that the two pictures formed in the right and left eyes, when looking at the same thing, are slightly *different;* for the simple reason that they are not seen from the same point of view. In order then, to obtain by these pictures the semblance of relief, we must present to each eye a different picture, similar to the one it would see in looking at the object itself. In other words, these two pictures (which we will call from now *stereoscopic pictures*) should be taken from two points of view, between which the distance is equal to the separation of the eyes. We shall see further on, that in some cases there is an advantage in augmenting this distance, in order to accentuate the relief; the conditions which these pictures ought to fulfil, and the manner in which they can be presented to the

eyes, form, however, the subject of this book.

A description of the eye* is not necessary, nor is a list of the various hypotheses already set forth in explanation of why the two impressions received upon the retina only give one single picture, and why it results in the perception of relief.

Physiologists, moreover, are not entirely agreed on the mechanism of the vision, and an intimate knowledge of these phenomena is not

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*We give herewith figures relating to the principal elements of the eye. They serve to show the point of view of the formation of pictures on the retina.

Radius of average curve of the anterior face of the crystalline lens	10 mm.
Radius of average curve of the posterior face of the crystalline lens	6 mm.
Average thickness of the crystalline lens, variable according to accommodation (Helmholz)	3 mm. 5.
Diameter of crystalline lens	9 to 10 mm.
Points of refraction crystalline lens (W. Krause) — Exterial layers	1,405.
Points of refraction crystalline lens (W. Krause) — Middle layers	1,429.
Points of refraction crystalline lens (W. Krause) — Nucleus	1,454.
Distance of retina from optical centre of crystalline lens	20 mm.
Focal length of crystalline lens in repose	45 mm.
,, cornea ,, ,,	32 mm.
Radius of curves of the cornea (Vallée) — Anterior face	10,075.
Radius of curves of the cornea (Vallée) — Posterior face......	8,68.
Point of refraction of cornea	1,33.
,, ,, aqueous humour (Sappey)	1,337.
Average diameter of pupil	3 to 4 mm.
Average distance between the eyes..about	65 mm.
Minimum distance of distinct vision ,,	20 cm.

necessary to attain our object, which is simply to present to each eye a picture as far as possible in the identical conditions offered by nature. Besides, we propose to look at things exclusively from a practical point of view.

It is easy to ascertain by very simple experiments, that binocular vision is necessary to the complete perception of relief, but that it is not the only thing necessary; in other words, that the distances can be roughly estimated with one eye, but that both eyes are necessary to estimate them with true approximation.

It is in this way that the distances of objects in a drawing are estimated, by looking on the dimensions given to them by perspective. It is the same in monocular vision.

A one-eyed person knows the distances of objects around him, because he has an idea of the size of those objects.

In the same way, if one eye be closed, objects near at hand can be easily grasped, but it would be very difficult to thread a needle, because the distance between the thread and the needle has to be exactly estimated in order to bring them together.

Suspend a small ring on a string, and take a long stick—a fishing rod for instance,—stand at a distance from the ring, and close one eye; then approach the ring, trying at the same time to put

the end of the rod through it ; you may try a long time before succeeding, if, after each failure you resume your original position and in no way allow yourself to be guided by the preceding trial.

Here is a much more simple experiment : Stick a pin into the table, at some distance from you, but within reach of your hand, place your

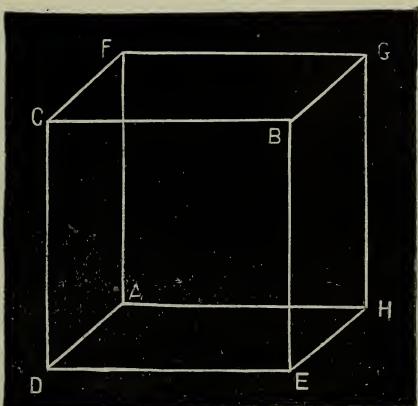

Fig. 1.

arm at your side, then, with one eye closed, try, without hesitation, to place the tip of the finger on the pin. Very probably you will put it either on one side, further away, or nearer to you.

Another experiment, suggested by Necker de Saussure, shows how difficult it is for one picture to give an exact representation of an object.

If a cube be drawn (Fig. 1) it can be seen in

two different ways. In looking at the point A, the face A F G H appears to be in front; but if, on the contrary, the point B is regarded, the face B E D C appears to be in front.

A similar design is shown in Fig. 2. By looking at face A, or at face B, as the case may be, the stairs are seen either in relief or hollow.

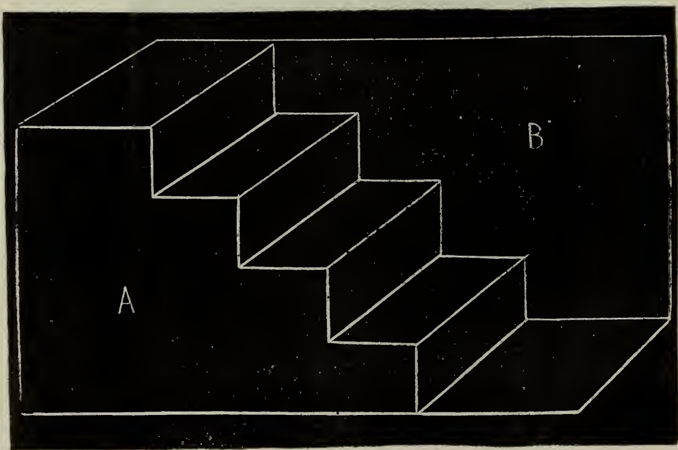

Fig. 2.

These experiments can be repeated in another form, by using solid objects, and looking at them with one eye. We have constructed a cube of wire, similar to Fig. 1. Painted white, and placed against a black background, it can be reversed at will, as easily as the drawing, if looked

at with one eye.* At whatever distance it may be placed, even at the minimum of distinct vision, the change can be easily produced, with one eye. If the cube be too near, the perspective of the picture so reversed would be false. If, while looking at a picture so reversed, the other eye be gradually opened, the cube will at once assume its true position, and it afterwards becomes impossible to see it otherwise. If a retreat be now made to some distance, the reversal can be produced as easily while using both eyes.† This is explained by the fact that the two pictures formed in the eyes are less different at some distance from the object, and that beyond a certain distance they are sufficiently alike for the appearance of relief to disappear almost completely.

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*A very curious observation arises from this experiment: We will suppose that in reality (Fig. 1) the face C B E D is in front, and that the reversing is effected so as to bring the face A F G H forward. If the head be moved, or if a turn be taken round the cube, it will appear to move at the same time. This illusion is easily explained by the fact that the vertical edges in the primitive cube have become oblique in the turned cube, and as they are bound to remain parallel with each other, the angle they make, along with the horizontal edges, varies when the position of the eye is changed, whence the illusion of rotation.

†The side of the cube which we used measured 30 mm. at a distance of about 3 m. 50, and it is possible to obtain the reversing when using both eyes.

These simple experiments, which show that the use of both eyes is necessary for the perfect appearance of relief, may be varied indefinitely; but if we wish to penetrate more deeply into the mechanism of binocular vision, we must have recourse to several instruments, which are, however, very simple, and which allow the conditions to be varied.

THE PSEUDOSCOPE.

THE PURPOSE OF JUDGMENT IN VISION.

IN looking at an object with one eye its depth is perceived by looking at it perspectively. In looking at it with both eyes the relief is complete, and becomes much more striking, because of the perception of two different pictures. But it is only by experience founded on preliminary experiments, that we learn to make use of this double phenomenon.

We have all seen that a young child in trying to seize an object will often join his hands in front of it, because he has not a true idea of his distance from it. It is only by many similar mistakes, and by comparisons between the senses of touch and sight, that he at last finds out the distances by sight alone.

The presence of a double impression (perspective and binocular effect) makes this estimate sufficiently sure. In cases where by some artifice the two impressions are rendered incompatible,

the judgment becomes fixed for a more lengthy period on that impression which predominates.

Suppose we are looking at the figure of a hexagonal pyramid. The picture impressed on the left eye will be A (Fig. 3), that on the right eye will be B. If the pyramid, instead of being in relief were hollow, the reverse would be the case, *i.e.*, B would be the left picture and A the

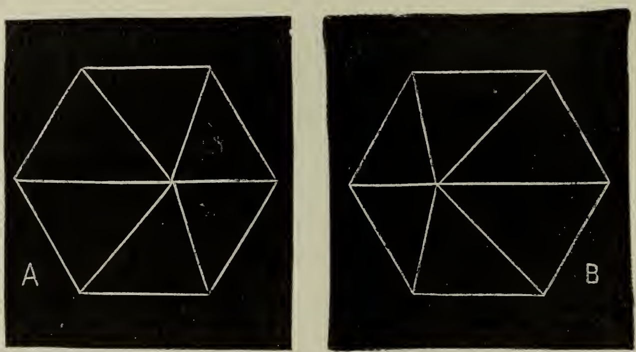

Fig. 3.

right. We can then suppose that if the right picture be presented to the left eye, and *vice versa*, the form of the object will be seen unlike its real one, *i.e.*, the hollow parts will appear in relief, and those in relief will appear hollow. But if the experiment be made, it will be found that this reversal takes place, though not in every case; because in order to produce the change it must be

as easy to picture the reverse form of a thing as the primitive one.

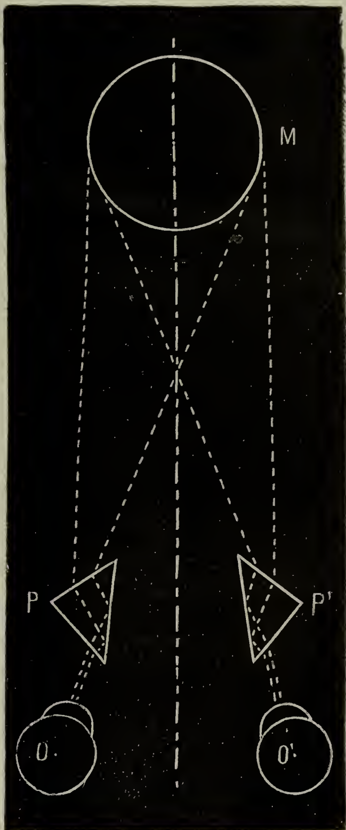

Fig. 4.

These curious effects are easily produced by the use of Wheatstone's *Pseudoscope*. This instru-

ment is formed by two rectangular flint prisms, P P' (Fig. 4), whose oblique faces measure about fifteen millimeters.* These two prisms are placed in such a position that their hypothenuses make between them an angle similar to that of the eyes. The object is looked at through these two prisms, which are set in such a way that the two pictures are superposed. In reality, the substitution of the right for the left picture does not take place, but on account of the reversal, the right picture takes the form of the left one. Take, for example, the pyramid (Fig. 3) of which we have already spoken. The right picture seen by means of the pseudoscope will be picture B turned round, *i.e.*, picture A. In this way we get the illusion of the hollow pyramid. At the same time, there are, as we have already said, certain objects which cannot be turned, because the reverse form is not conceivable. Thus in looking through a pseudoscope at a plaster medallion, it is easy to think that it has the form of a mould, *i.e.*, that it is hollow; but it is impossible to get the reversal of a living figure. It also often happens that the effects of shadow give inadmissible pictures. A medal with the face strongly lighted is a very good object with which to make the experiment.

Helmholz has suggested, also, the use of a

* The apparatus represented in Fig. 71 might be used as a Pseudoscope.

graduated glassguage, with the divisions on the side next the observer (the convex side). Examined through a pseudoscope, the guage will appear to be divided on the other (concave) side.

A pseudoscope which really presents the right picture to the left eye, and *vice versa*, is easily made. We only need four mirrors, or still better, four prisms of total reflection. We place prism P (Fig. 5) with its face to the left eye, and set it in such a position that it reflects the picture into another prism, P' placed before the right eye. We shall obtain the same results by using Wheatstone's instrument, except that objects will be seen in their true form.

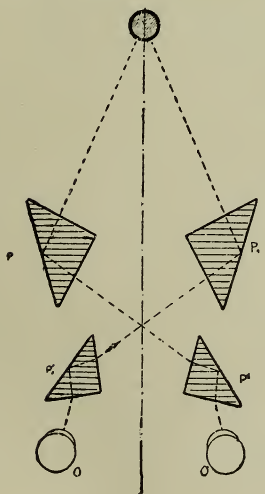

Fig. 5.

We shall see further on that the reversal of relief is also effected through the stereoscope by presenting to both eyes, not the objects themselves, but photographs of them.

THE TELESTEREOSCOPE AND THE ICONOSCOPE.

THE perception of relief obtained by binocular vision proceeds from the difference in the

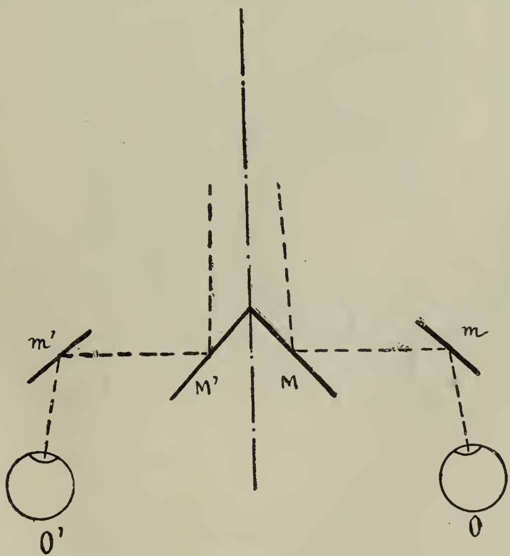

Fig. 6.

form of the two pictures. If, by the aid of an appropriate instrument, we present to both eyes

two pictures seen from the same point, and therefore alike, the appearance of relief will immediately disappear. The iconoscope, invented by Javal (1866), helps to prove this. This instrument (Fig. 6) is formed of a double mirror, M M', which reflects the pictures of objects into two other mirrors, m m', placed at a distance from each other equal to the separation of the eyes. Objects looked at with this instrument assume the appearance of a flat painting, even in a more pronounced degree than in monocular vision. On the contrary, a drawing looked at with the iconoscope gains relief.

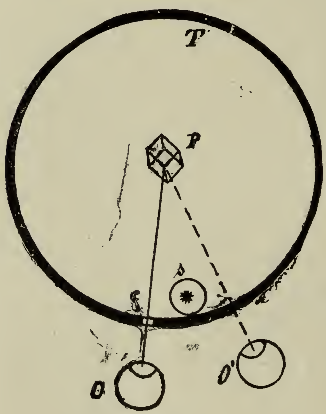

Fig. 7.

We have constructed an iconoscope of a different form. Fig. 7 shows its principle. A drum, T, with a vertical axis rapidly rotates round this axis. The object, P, which is to be observed is fixed in the centre of the drum and turns with it. Through a hole, f, which is made near a generator, we can see the object, P. The eyes, placed at O O', will successively see the object, P, through the hole, f, as the drum rotates;

and as they will each see it in exactly the same position, the image will appear to be without relief. In order that the object, P, should be lighted in the same way in both cases, the source of light should be fixed in such a way that it will turn with the drum.

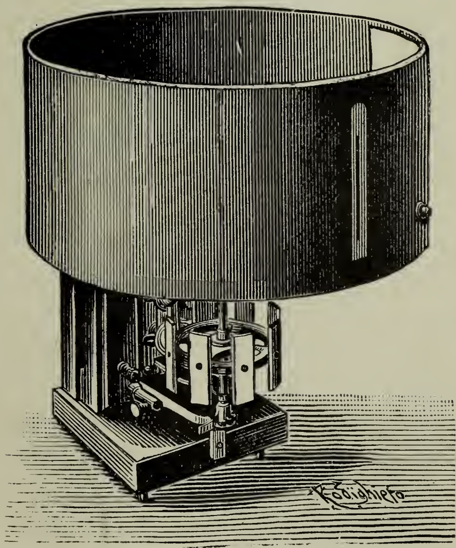

Fig. 8.

Fig. 8 illustrates this iconoscope. The drum is set in action by a small electric motor, and the object is fixed in the interior by means of screws and holdfasts. It is lighted by an incandescent lamp which rotates along with it, and which is

supplied from outside by the aid of a plate which rubs against an insulated coil. The speed of rotation should be from thirty to forty turns in a second. A most interesting experiment is made by placing in the apparatus the small wire cube already mentioned (Fig. 1). This cube, seen in the iconoscope, and at the minimum distance of distinct vision, is absolutely without relief, and can be seen reversed as easily as in the case of the drawing.

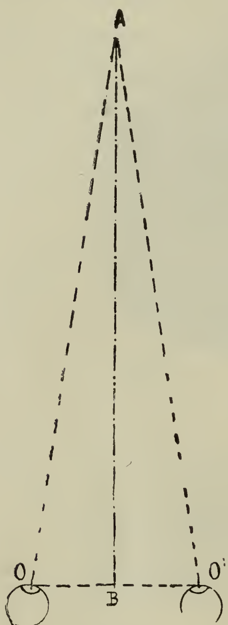

Fig. 9.

The relief of an object seen with both eyes becomes more pronounced the more the two pictures differ; in other words, it augments at the same rate as the angle O A O' (Fig. 9), or the *optical angle*. This explains why the form of an object near at hand is so much more easily seen than that of one at a distance, even when the latter is greatly enlarged (as by means of an opera glass). The most perfect perception of relief is obtained when the object is placed at the minimum of distinct vision. From a longer distance the relief is, practically speaking, no longer perceived; and if we attempt to estimate

the distances between any objects it is by first deciding on their probable dimensions.

These facts are made use of in arranging panoramas (such as Niagara in London, Battle of Waterloo, etc.), where the nearer parts are represented by real objects, and those further away by the painting, arranged in such a way that

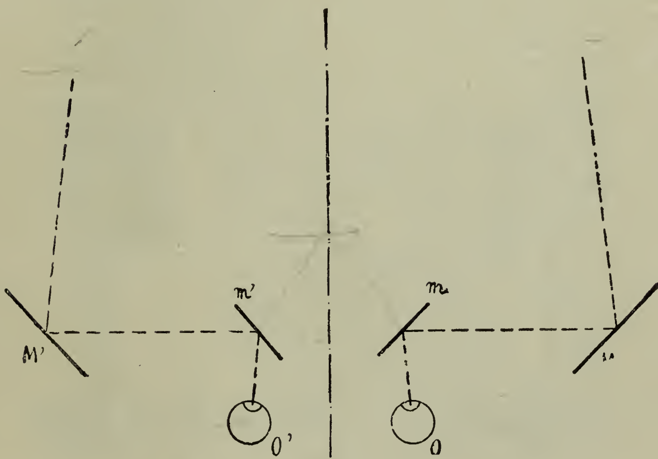

Fig. 10.

the spectator can scarcely tell where the reality terminates and the painting begins.

The *telestereoscope*, invented by Helmholz, 1857, is an apparatus the function of which is to increase the relief of distant objects by enlarging the optical angle in the following manner :—

Two mirrors, M M' (Fig. 10), are placed at a

distance from each other much greater than that of one eye from the other. Two other mirrors, m m', reflect into the eyes the pictures shown in the mirrors, M M'. The perception of relief is as great as if the separation of the eyes equalled that of M M'. It is evident, therefore, that the telestereoscope produces precisely the opposite effect to the iconoscope. Telestereoscopes have

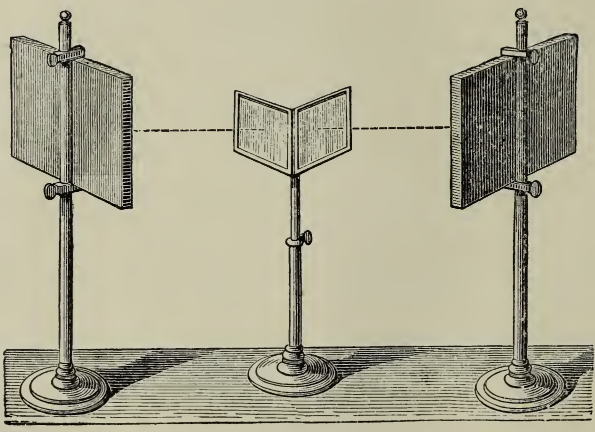

Fig. 11.—Telestereoscope.

been constructed by simply mounting mirrors on supports (Fig. 11), but it is better to enclose the whole in united tubes or in a box (Fig. 12).

Claudet in 1860 fitted opera glasses with four prisms forming a telestereoscope, thus magnifying the depth as well as the length and breadth. In

using an ordinary glass the appearance of depth in distant objects seems to be reduced, which

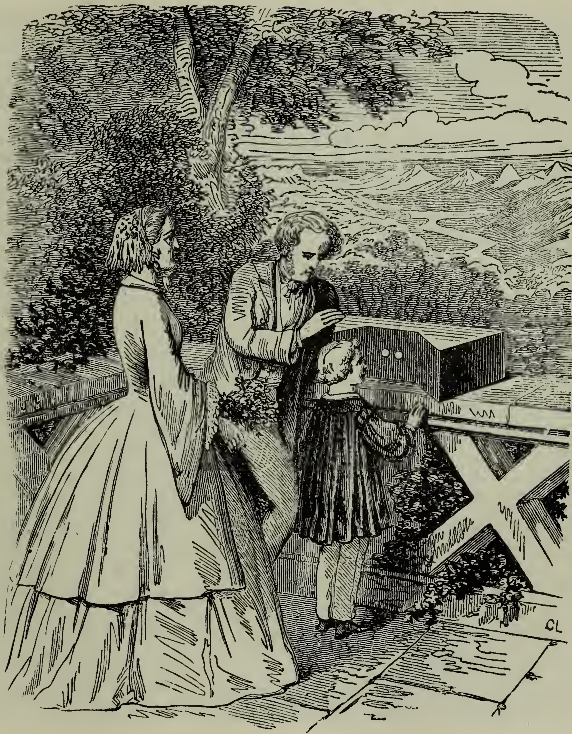

Fig 12.—Telestereoscope.

proves that the optical angle is less than it would be if the objects were seen directly and in the same dimensions.

The relief of an object can be varied in a very simple manner by looking at it through two thick

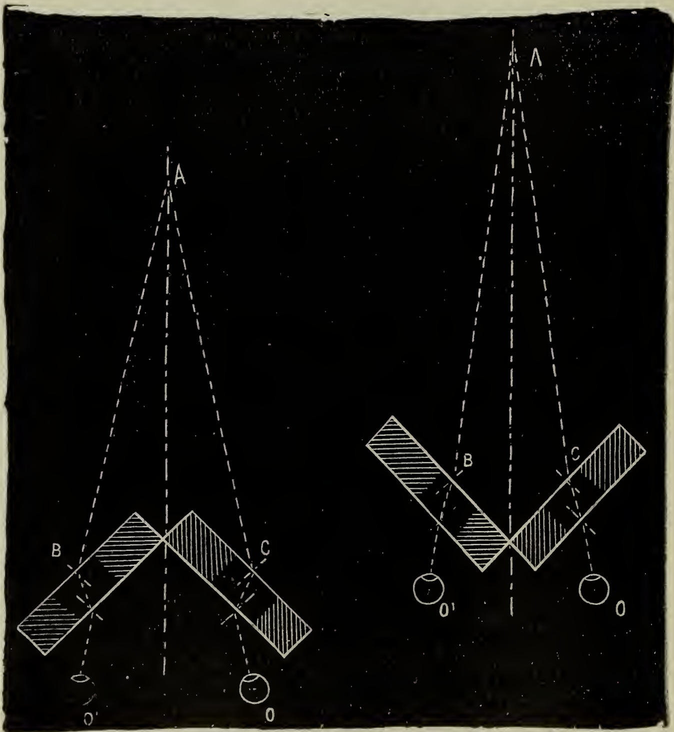

Fig. 13. Fig. 14.

glasses, inclined in accordance with the eyes. The relief is increased by looking at the object from the interior of the angle formed by the two

glasses (Fig. 13). On the contrary, by looking at it from the exterior the relief is diminished (Fig. 14). On referring to the figures opposite, it will be seen that the optical angle is really increased in the first, and diminished in the second case.

THE STEREOSCOPE.

IF we could obtain two pictures of the same object, such as would be seen by the two eyes, and could look at each picture with the corresponding eye, a single picture would be seen, giving an effect of relief as though the object itself were before our eyes. We get this result by the use of the *Stereoscope*.

Primarily it may be thought that once the images are obtained, it is sufficient to place one of them before each eye to secure immediately the resultant picture ; but such is not the case ; the eyes converge naturally and fix on the same point, refusing to look in a parallel direction so that each may see a separate picture. Even if a screen be placed between the two pictures, so as to hide from each eye the one it ought not to see, both eyes would instinctively converge towards a point. It is possible to make the eyes look parallel, but the performance involves painful optical gymnastics and to avoid this the stereo-

scope has been invented. The stereoscope is, then, an apparatus which, having two pictures placed in it, while permitting one to be seen by each eye, allows the two eyes to converge at a certain angle, as in ordinary sight.

The stereoscope has been made in numerous forms; we shall describe the most notable without maintaining any historical order. Stereoscopes of projection will be dealt with in a subsequent chapter, at present we are only concerned with *stereoscopes of direct vision.*

Refracting stereoscopes are only employed somewhat exclusively, and photographers have been led to mount stereoscopic views in the ordinary manner, for the use of these instruments. We shall, however, describe various other forms of the stereoscope, which, while not always permitting the use of ordinary stereographs, possess numerous interesting peculiarities.

THE REFLECTING STEREOSCOPE.—This instrument which formed the turning-point of stereoscopic science was invented by Wheatstone in 1832. It is formed of two vertical mirrors M M' (Fig. 15) inclined to one another at an angle of 90 degrees.

The pictures to be examined are placed at E E', and a screen pierced by two holes *t t'*, indicates the position of the eyes, and only allows the rays forming the corresponding picture to pass

to each eye. A glance a Fig. 15 shows that two similar points *g d*, belonging to each picture, combine at *r* in the true picture.

Fig. 16 represents the usual form of reflecting stereoscope. The pictures G D are placed on supports, movable horizontally and vertically, so that the position may be exactly regulated. A

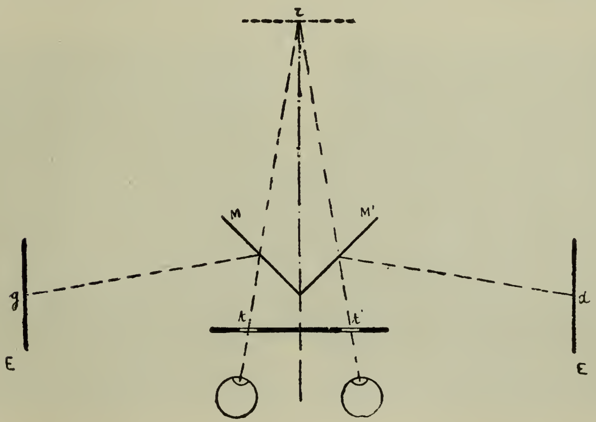

Fig. 15.

and B are mirrors (their angle may be varied in some instruments). E and F are openings and are sometimes furnished with lenses intended to magnify the pictures.

The stereoscopes used by Wheatstone were at first made for the examination of drawings; as the pictures were reversed by the mirrors they had to be drawn accordingly. Photographs can

be examined by it equally well ; but it is necessary in that case also to use reversed prints. Although there is little difficulty in obtaining reversed photographs, it is also possible to use ordinary prints in a reflecting stereoscope, by putting the right hand picture to the left eye and *vice versa.*

The result will then be seen reversed and possessing true relief.

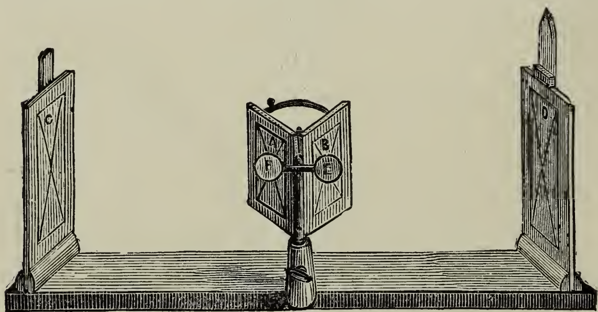

Fig. 16.

In order to understand this transference of the pictures, let *g d* be views of the end of a pencil seen flat (Fig. 17).

Suppose then that the left picture *g* is placed on the left in the stereoscope. After the reflection in the mirror, the perspective of this picture will be inverted, and it will appear as though seen by the right eye. In the same way, the right picture *d* will take the left perspective. In the case of a

symmetrical object seen full face, the substitution of the pictures can be made without altering the form of the object; such would be the case with the end of the pencil, of which we are speaking; but if it be a landscape, it will be seen reversed unless, as before mentioned, reversed pictures be used. The inconveniences of the instrument, together with the necessity of experimenting in

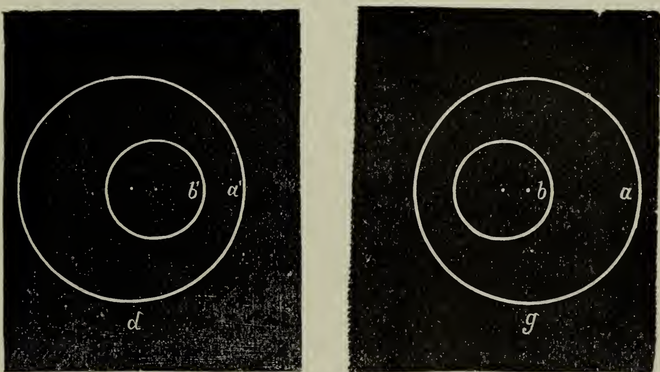

Fig. 17.

order to obtain combination, have led gradually to its disuse. It has, however, the advantage of allowing pictures of any dimensions to be used. At the same time, in the case of very large subjects, it would be necessary to increase the distance, and the size of the instrument to such an extent that it would become cumbrous. To guard against this inconvenience, it has been suggested

that the pictures should be hung on opposite walls of a room, and nothing but the central part of the instrument retained. In this case there is not only a difficulty in regulating, but the lighting of the pictures is unequal.

The instrument is generally made with mirrors silvered on the under side, with the result that a double picture is often evident; this fault may be remedied by the use of metallic mirrors. Brewster has remedied it still more perfectly, in replacing the mirrors by prisms of total reflection.

Wheatstone's stereoscope is perfectly adapted for the examination of transparencies; the only modification necessary is to replace the two supports by frames fitted with ground glass. Flashed opal glass gives a still better effect. The lighting is secured in this case either by two lamps placed one on each side of the stereoscope, or two joined mirrors. In all cases it is better to mount the apparatus on an adjustable stand, so that the transparencies can be brought to the height of an ordinary lamp. This elevation of the stereoscope makes it easier to use on a table, as it places the mirrors on a level with the eyes of a seated person.

Total Reflection Stereoscope.—Duboscq invented this stereoscope for the examination of large pictures. It is formed of two isosceles prisms P P', the use of which will be readily

understood by aid of Fig. 18. The two images *g d* give at *r* the resulting picture.

The pictures can be enlarged by lenses placed before the eyes. It will be seen that this instru-

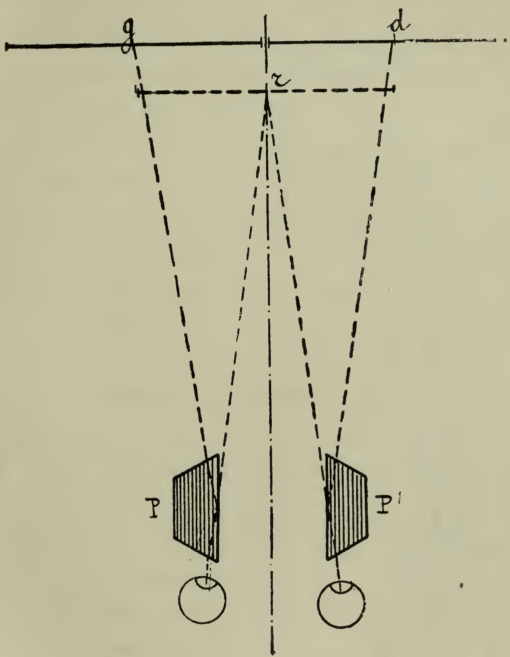

Fig. 18.

ment permits the use of two pictures placed on the same level. It is better, therefore, to mount them on one card, in order to avoid adjustment afterwards, the pictures being once for all put into position in reference to each other.

Direct Stereoscopes.—Eliott & Waterston invented a stereoscope which brings about the perception of relief without the interposition before the eyes of any instrument either reflective or refractive.

It is composed of a box B (Fig. 19) open at C C'. In the opposite end two holes are pierced, having a distance from each other corresponding with that of the eyes. The dimensions and position of the opening C C' are so determined that the right eye can only see the picture placed at the left, and the left eye that on the right. The sides of the opening C C' are fitted with keys, with which to regulate the dimensions according to size and distance of the objects. This instrument profits by the natural tendency of the eyes, in ordinary vision, to converge towards the same point, but, as it exacts the convergence at a certain distance, some effort is necessary to bring about the desired result. In

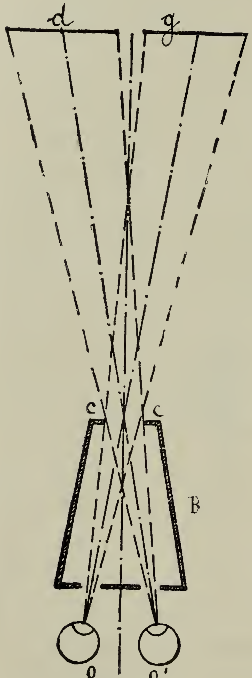

Fig. 19.

fact, the eyes, accustomed to look at the plane *g d*, must converge as if they were looking at the plane C C', which is much nearer. It is therefore evident that, at first, it will prove difficult, the conditions differing from those of ordinary vision. To facilitate the adaptation a small object should be placed at C C', and looked at first, so that the eyes become forced to take the desired convergence.

Steinhanser constructed a similar stereoscope, furnished with either lenses or portions of concave lenses, in such a way as to allow a normal accommodation for a given convergence. This instrument really constitutes a refracting stereoscope contrary to that of Brewster.

Volpicelli also invented a direct stereoscope, which he named the *Diaphragmatic Stereoscope*. It is composed of a box 62 centimètres long, 20 broad and 11 in height, of which one of the small ends is pierced with two holes, the opposite end receiving two stereoscopic pictures. Two vertical screens, movable round the vertical angles of the first end, serve to limit the compass of each eye.

TELESCOPIC STEREOSCOPE.—H. de la Blanchère gave his name to a stereoscope of his invention, similar to the preceding ones, but more perfect, because it allows accommodation, corresponding to the convergence to be obtained.

Its appearance reminds us of an opera-glass (Fig. 20). The two lenses of which it is formed are mounted on hinges which allow the adjustment :—

1st. Of the distance between them to suit the distance between the eyes.

2nd. Of their inclination, in such a way as to make both look at the picture.

3rd. Of their convergence.

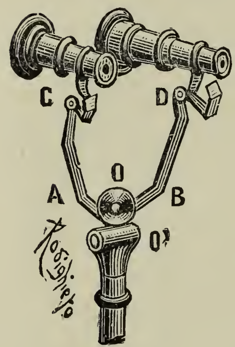

Fig 20.

When the apparatus has been properly regulated, and the two glasses put in position by these numerous movements, superposition is easily obtained.

Zinelli (1857) used ordinary opera-glasses for examining stereographs, but it is evident that if these are fixed for looking at an ordinary object an effort will be essential to bring about superposition.

Double Total Reflection Stereoscope.—Girard-Teulon (1861) invented a stereoscope whose form recalls the telestereoscope of Helmholtz. It consists of four total reflection prisms arranged as indicated in Fig. 21. Their duty is to separate the two visual axes at such a distance as to allow

the examination of large pictures, the two prints G D being placed in the usual position. Two ordinary prisms P P' placed before the eyes produce the desired convergence.

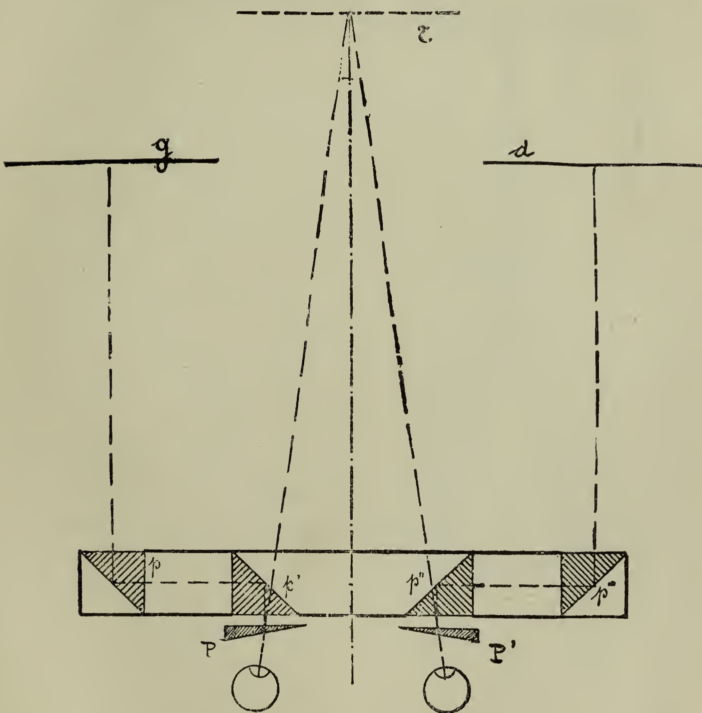

Fig 21.

Refractive Stereoscopes.—These instruments are those almost exclusively employed at the present time. They allow the use of prints

mounted on one card,* and placed in their natural position, that is, the right picture at the right, and the left at the left of the observer.

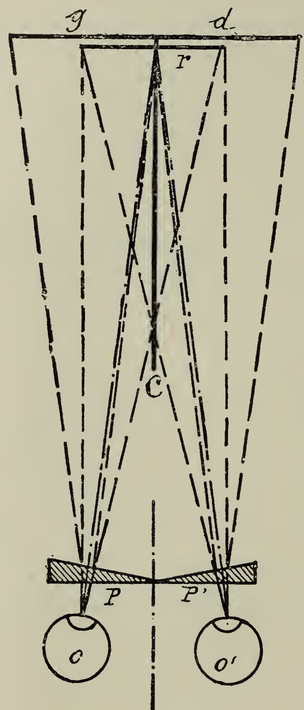

Fig. 22.

g d are the two pictures and P P' two prisms fixed together by their angles (Fig. 22). If the angle and position of each prism be conveniently fixed, two similar points of the pictures *g d*, will be seen at the same point *r*, and then superposition and stereoscopic relief will be obtained.

In the apparatus formed simply of two prisms, each eye naturally sees both pictures, the left eye will see them refracted to g^1 d^1 and the right eye to g^2 d^2 (Fig. 23). (The two pictures have been

* The name stereograph is often given to the right and left pictures thus mounted side by side.

drawn one over the other for greater clearness.)

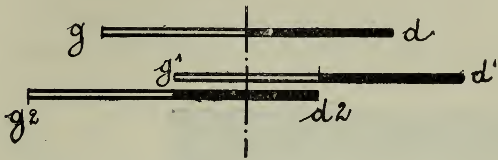

Fig. 23.

The pictures g^1 and d^2 superpose each other to give relief, but the pictures d and g^2 remain visible at each side of the former. This causes no serious inconvenience, but the lateral images can be done away with by placing between the two prisms an opaque partition C, perpendicular to the picture (Fig. 22).

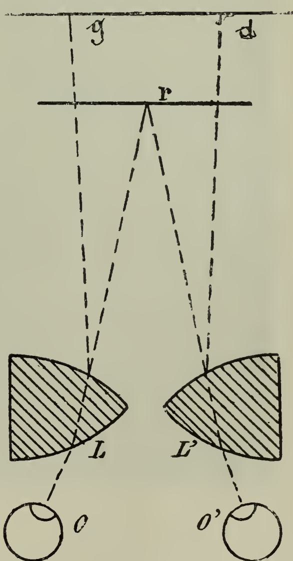

Fig. 24.

Brewster (1844) improved this apparatus by replacing the two prisms with two prismatic lenses, which both magnify the pictures and produce the desired refraction (Fig. 24).

These prismatic lenses are made as follows:—Cut in two, following a diameter D D' a lens L of about 10 centimètres in diameter and 20 centimèters focus. Then trim the two halves as indicated in Fig. 25, so as to make them rectangular, and fix them together by their small edges. When thus fixed they should be about 80 millimètres wide ($3\frac{1}{8}$ in.), the least separation of the eyes being 65 millimètres ($2\frac{1}{2}$ in.) The sharp edges of the two half lenses can be left and inserted in the mounting (Fig. 26). Brewster inserted two halves of the same lens into one stereoscope so as to be certain of obtaining the same focal length on each side. In practice it is not necessary for this condition to be

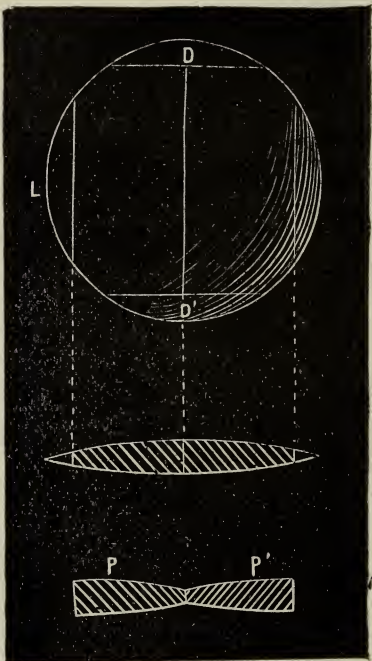

Fig. 25.

exactly adhered to. In looking by ordinary sight in a lateral direction at the object M (Fig. 27), the eyes O O' are at different distances from it, and the two pictures reflected on the retina are, therefore, not of the same size, but this does not prevent the easy perception of relief.

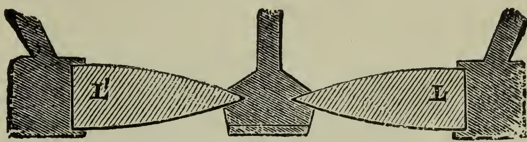

Fig. 26.

We should therefore expect to find the same elasticity in stereoscopic vision, and this is, in fact, the case. Although the two pictures may differ slightly in size there is no difficulty in seeing them properly in relief. Complete lenses may be employed instead of halves, and this may facilitate the construction of the apparatus. It is interesting to notice that a bi-convex lens acts in regard

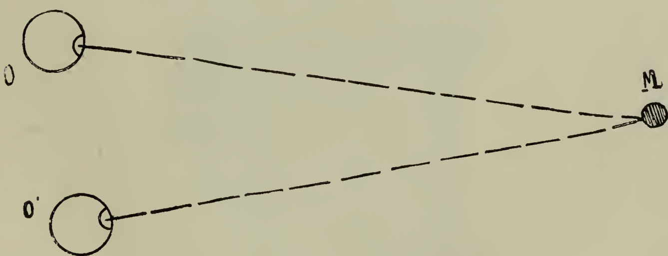

Fig. 27.

to divergence in the same way as a prism, the deflection of which is nil in the centre, but increases in crossing till it reaches a maximum at

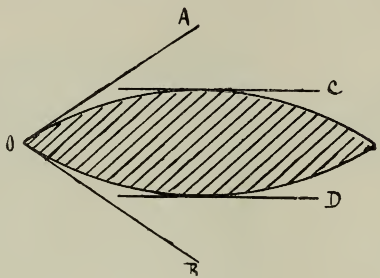

Fig. 28.

the side (Fig. 28). It follows therefore that in varying the position of the eye, with reference to

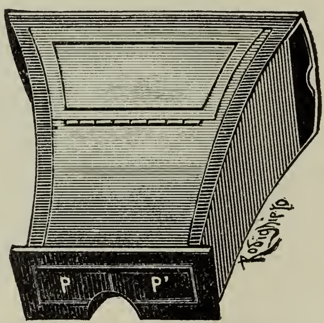

Fig. 29.

the centre of the lens, the divergence sustained by the picture will be varied at the same time. By making the two lenses movable laterally, the

divergence can be regulated, and the exact superposition obtained without effort.

We must now describe the various forms in which Brewster's stereoscope has been constructed, and they are numerous.

Fig. 29 shows its original form. A wooden box holds the prismatic lenses P P' on its front surface.

The pictures are placed at the opposite end, a slit being left in the side for the insertion.

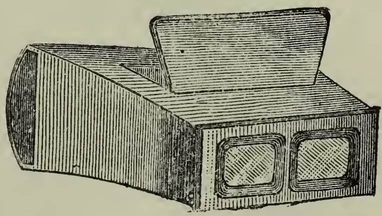

Fig. 30.

One part of the top of the box consists of a door on hinges, which can be opened to allow light to fall on the picture, and the interior face of this door is fitted with a mirror. The use of the box is to keep out all light except that reflected by the mirror, in order that the face of the picture may be well lighted.

On the under side of the lenses there is a hollow, indented to fit the nose of the observer, so as to allow the instrument to be brought close to

the eyes. This precaution, often neglected, is, however, of real use.

Figs. 30 and 31 are models of stereoscopes with prismatic lenses, which until comparatively recently were the forms usually sold in this country.

They are made like the preceding one.

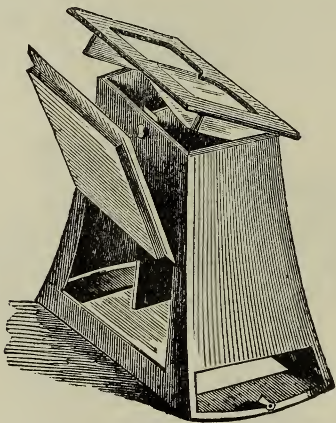

Fig. 31.

The front can be removed or opened, for the prisms to be cleaned; the opposite end is fitted with ground glass,* so that the apparatus serves either for transparencies or for ordinary photographs.

* Duboscq was the first to construct a stereoscope with ground glass at one end, for the use of transparencies.

Fig. 32 represents a stereoscope with entire lenses. These are mounted in a double framework, movable by the aid of a screw or rack, so that the instrument may be adapted to all sights. In reality the focussing is not very necessary, as the stereoscope once focussed for normal sight, will serve for either a short or long-sighted person, if they wear their usual spectacles. The

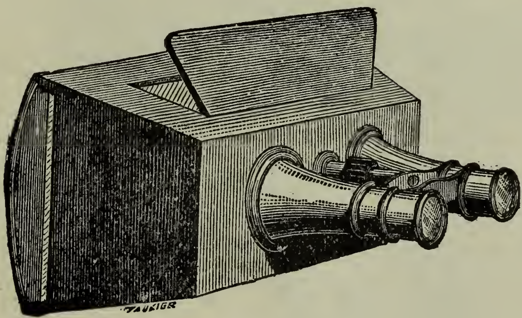

Fig. 32.

adjustment of the lenses is not, however, without its use, for by varying their distance from the picture, the refraction of the rays is also varied, so that generally a distance can be found at which the two pictures are superposed perfectly and without effort. We have frequently found that in this kind of stereoscope, the changing of the lenses is much more useful for this *stereoscopic adaptation* than for its proper use of focussing.

All these stereoscopes can either be used in

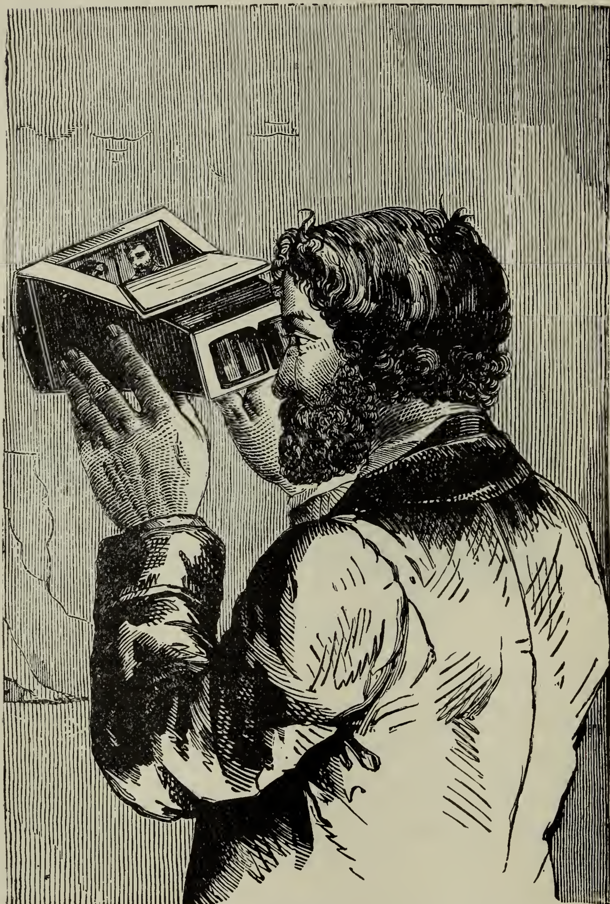

Fig. 33.

the hand (Fig. 33) or mounted on a stand.

M. Donnadieu has improved the ordinary stereoscope* so as to allow it to be used for other pictures besides those mounted on a card of the ordinary shape. To do this he has mounted the roughened glass on a movable frame, which can be separated from the box of the stereoscope.

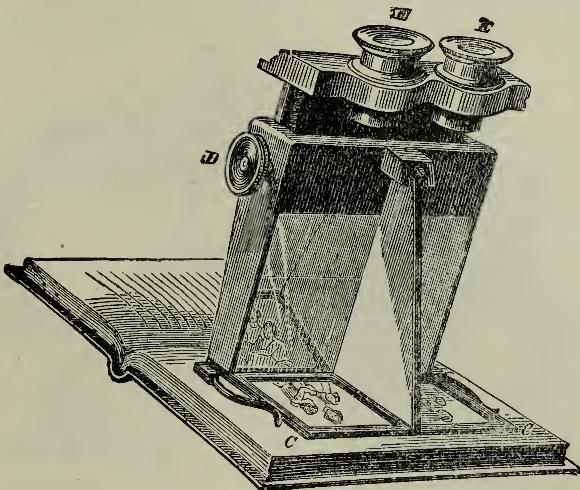

Fig. 34.

Fig. 34 shows another form of refraction stereoscope, also useful for examining pictures mounted in any sort of way. There is no box, but the whole apparatus is fixed on an upright frame.

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* A. L. Donnadieu, "Traité de Photographie Stéréoscopique."

Fig. 35 represents a pattern in which the separation of the lenses can be varied, one of them sliding laterally. This modification is very important : it is the only one known to us which permits a rational adaptation to all sights. The idea is by no means new, and it is strange that this stereoscope is not in greater demand.

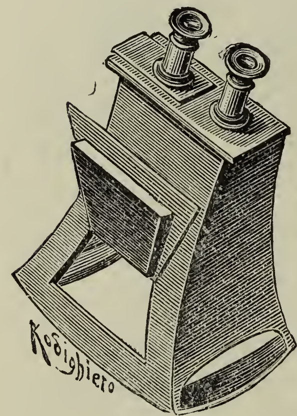


Fig. 35.

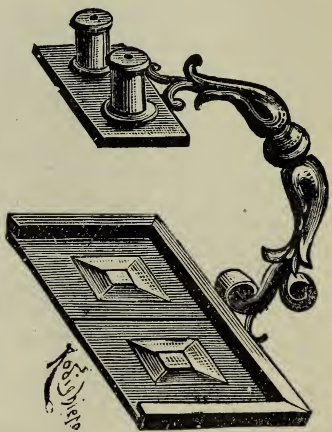


Fig. 36.

Fig. 36 represents another old form of stereoscope, in which the box is absent. The apparatus thus gains in elegance, without losing many of its other qualities.

The American stereoscope consists of a flat wooden base board, furnished with a handle. At one end the prismatic lenses are fixed, at the other is a frame intended to hold the photographs.

This frame can be moved backwards and forwards on the baseboard for the purpose of focussing. (Fig. 37).

This form of stereoscope has now become enormously popular in England and America, and, in fact, all over the civilized world. The demand for it has been extraordinary, and comparatively few households are without one. The cost of this

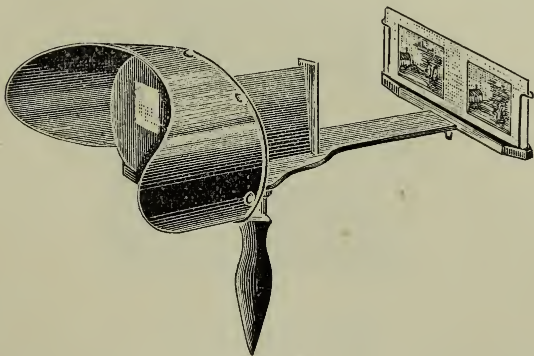


Fig. 37.

pattern is very low, about half-a-crown, or even two shillings for the cheaper makes, is the usual retail price.

Duboscq (1857) invented an interesting modification, which renders adaptation to all sights possible without varying the distance between the two optical systems. In his stereoscope the lenses are only used for magnifying, and the refraction is produced by prisms placed in front of them. The

lenses can be moved backwards and forwards for the necessary focussing, and each prism is in reality divided into two, which permits the refraction to be varied by a process as follows:—

If the two prisms, P P' (Fig. 38), having the same angle, α (the cylindrical form is used to facilitate mounting in the frames), are placed one

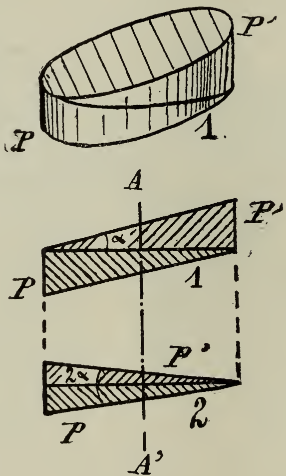


Fig. 38.

on the other, they will, when united, form a plate with parallel faces, and consequently without refraction, if they are placed to fit each other, as in position 1.

If the prism P' be turned 180 degrees round the axis, A A', the two prisms will then have an angle, 2 α, and will produce the maximum refraction

(position 2). Between these two positions lie all the intermediate refractions. This system, already applied by Rochon to his *diasporamètre*, has been adapted by Duboscq to his stereoscope with separate prisms and lenses. For the proper working, the edges of the frames are toothed, and fitted with a toothed wheel. A pinion touches both wheels at once, so that by a single turn symmetrical regulation is effected. Fig. 39, however, shows the whole of the mechanism. The side button, C, serves for focussing; the under

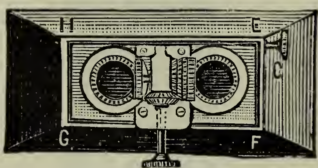


Fig. 39.—Duboscq's Stereoscope.

button does the regulating. In Duboscq's stereoscopes the angle α in each prism was 12 degrees. The rotation thus varies the angle from 0 to 24 degrees. Duboscq proposed the use of prisms achromatised by each other, which would suppress, or, at any rate, diminish chromatic aberration in the white parts of the pictures. It has been noticed, also, that the aberration of the lenses tended to distort the pictures in a way contrary to the distortion produced by the prisms, so that one corrected the other.

A short time before (1857) M. Jequezel also described a stereoscope with separate lenses and prisms.

Gerard (1859) placed behind the stereoscope coloured glasses which could be raised or lowered, in front of the photographs, to produce different effects.

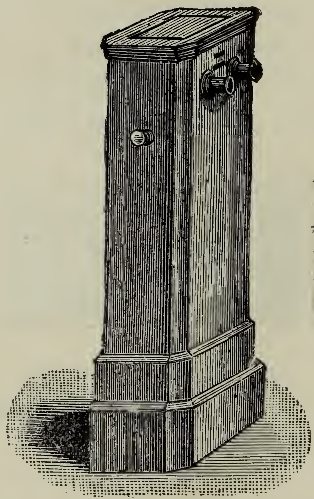


Fig 40.—The "Column" Stereoscope.

Cassaignes (1863) produced the same result by colouring the prisms or lenses, or by interposing coloured glasses before the eyes.

Grillet (1855) suggested the idea of putting a diaphragm inside the stereoscope, so as to allow the picture only to be seen without the surrounding white card.

Fig. 40 represents the "column" stereoscope. It is formed of a high box, in the upper part of which are placed the lenses of a stereoscope. A circular chain, worked from outside by a button, holds the photographs, which can be passed successively before the stereoscope. Some instruments will hold as many as 200 photographs. These stereoscopes, which really form a piece of drawing-room furniture, are generally made ornamentally, in accordance with their surroundings.

A pleasant variation applied by M. Méheux to the "column" stereoscope, is made by fitting the instrument with two sets of stereoscopic lenses, mounted on the opposite sides of the box. Instead of putting only one photograph in each frame, two are fixed back to back, so that two persons can use the apparatus at the same time. After looking at one half of the pictures, the other half can be seen by using the other stereoscope.

Under the name of *graphoscope* a combination has been designed, consisting of an ordinary stereoscope and a magnifying lens of large size (Fig. 41): this lens being intended for the examination of ordinary photographic views.

The instrument is represented open, and when closed looks like a flat box, the lid of which is formed by the end containing the lenses.

In 1857 Duboscq constructed a *portable stereoscope* made in cloth, which opened and closed by the

same mechanism as used in an opera hat.

A pocket stereoscope can be made in the same way, formed of a box without bottom, whose

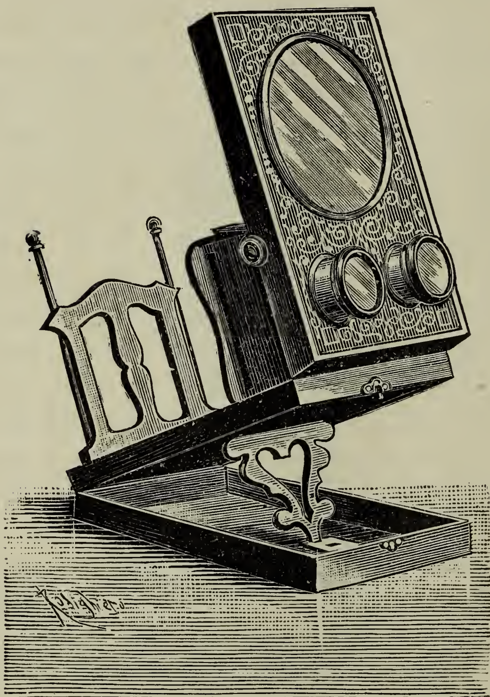


Fig. 41.—Graphoscope.

sides fold up. When closed it occupies no more room than an ordinary pocket-book.

We have devised the stereoscope represented in Fig. 42 to meet the requirements of all sights,

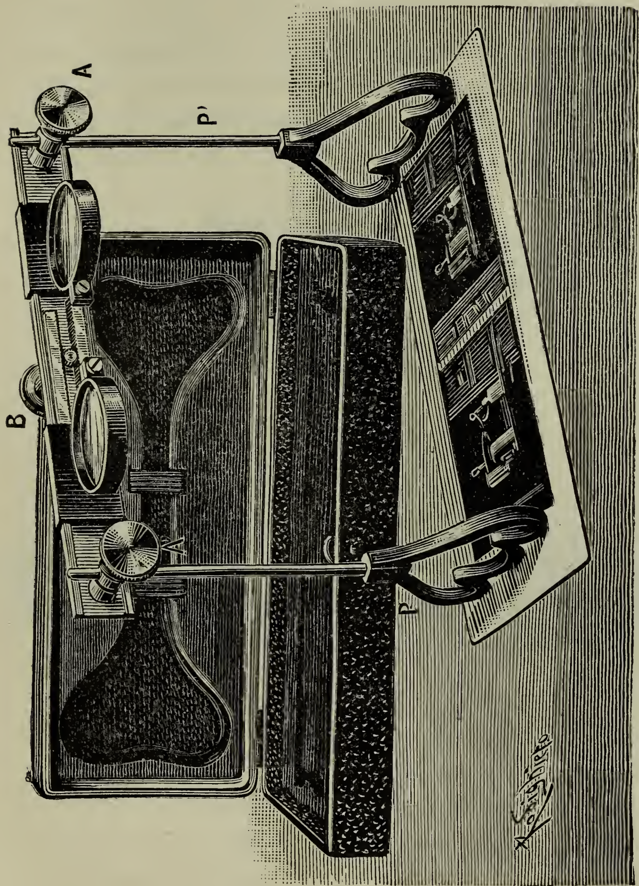


Fig. 42.

and to permit the use of all photographs, whether mounted on cards in the ordinary way, collected in an album, or printed in a book. It is formed of two lenses of variable distance. The framework is fixed on two feet, P P'. We prefer instruments of this unrestricted kind to those where the photograph cannot of necessity be moved vertically,

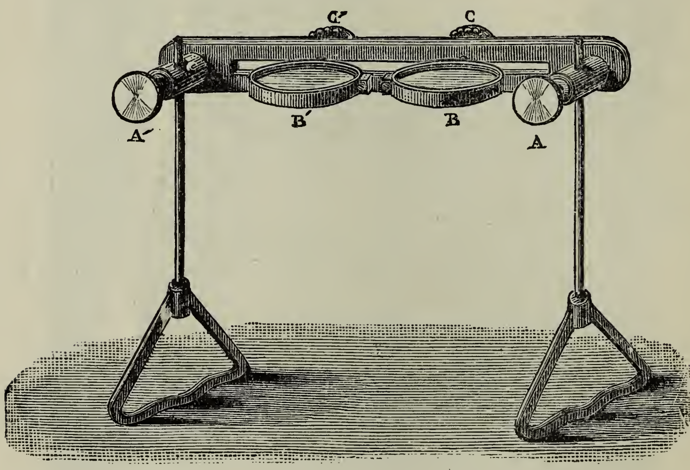


Fig. 43.

for very often the photographs which one buys are not fixed on the cards at exactly the same height. The stereoscope has then to be slightly leaned, in order to obtain the relief more easily. The adjustment in width is found by varying the separation of the lenses with the aid of the button B, which acts on two racks.

In the more simple model shown by Fig. 43, the lenses B B' are moved by the hand. The instrument can be made higher or lower on the feet which hold it, so as to regulate the focussing for all sights. These feet can be removed, so that the dismounted stereoscope can be packed into a small case.

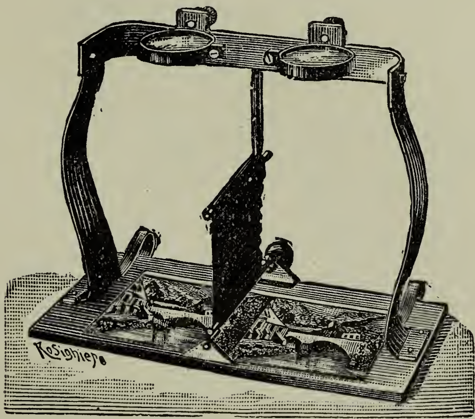


Fig. 44.

Fig. 44 shows us another form of stereoscope of variable separation, which answers the same purpose, but is not dismountable. The base is formed of a frame on which the photographs are fixed by two clips. The plane of the lenses is joined to this frame by two supports, which can be more or less bent for focussing purposes. To effect this, a band of black cloth (which forms at

the same time a screen between the two pictures) extends from the top to the bottom, where it is rolled on a small eccentric wheel. Focussing is effected by this wheel. The eccentric wheel is to prevent the cloth unrolling under the action of

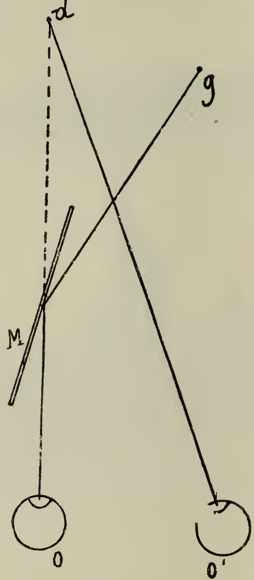


Fig. 45.

the supports, the balance of the whole being restored after each complete turn.

SUNDRY STEREOSCOPES. — We have now examined the more usual forms of the stereoscope; but there are others which, though not very

practical, are still very interesting, and worthy of brief mention.

Fig. 45 shows a scheme for the construction of a stereoscope with a *single mirror.* The right eye looks directly at the right picture *d*, placed at the left. The left sees in a flat mirror M, the left

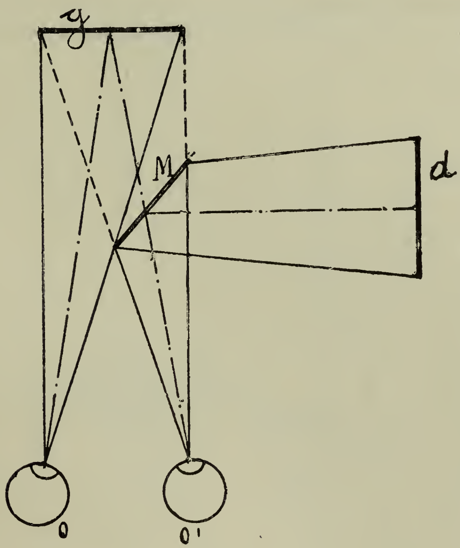


Fig. 46.

picture *g* placed at the right. This last picture should be reversed, so that it can be seen in its true form, after being reflected in the mirror M. To allow for the difference in the distance from the two eyes, the picture *g* is placed a little nearer the mirror.

Corbin (1861) made a stereoscope with a *single mirror* differently constructed (Fig. 46). The photographs are placed at *g* and *d*, perpendicularly to each other. The picture *g* is seen directly by the left eye O; the picture *d* is seen in a mirror M. This latter should be reversed. Larger pictures

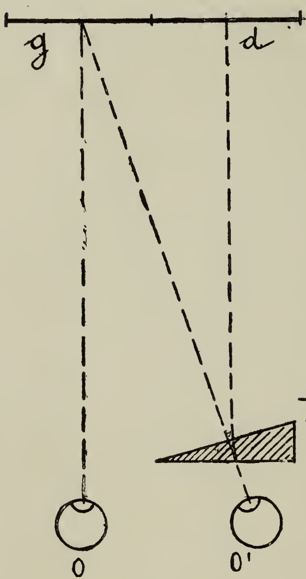


Fig. 47.

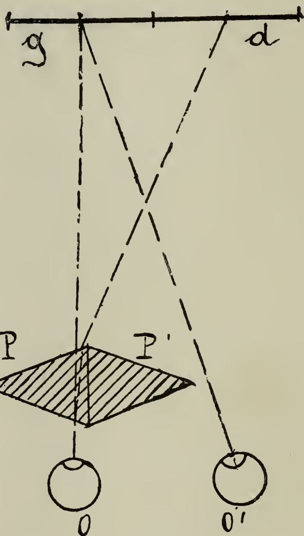


Fig. 48.

than ordinary can be used with this instrument.

It may be mentioned, that in stereoscopes of this description, the position of the photographs can be changed by merely reversing the pictures.

Brewster designed stereoscopes with a *single prism* (Fig. 47). But it is better to produce the

refraction by *two* prisms, the distortion and chromatic aberration being less.

Brewster also designed a stereoscope with *two prisms joined together by their bases* (Fig. 48), which can also be used as a pseudoscope. To obtain relief the right picture *d* should be looked

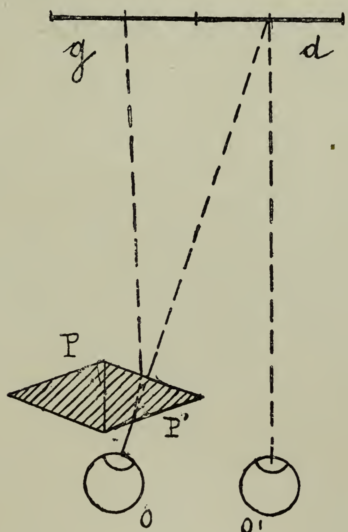


Fig. 49.

at with the left eye, and the picture *g* through the prism P'. The apparatus then acts in the same way as the preceding stereoscope with a single prism.

The pseudoscopic effect is obtained by looking at the right picture with the left eye through the

prism P, while the right eye looks directly at the left picture (Fig. 49).

M. Ducos du Hauron invented a stereoscope *for coloured pictures*, formed of two glasses of complementary colours (red and green).

The pictures to be looked at are also drawn in two colours, a transparent colour being used for one of them, and they are superposed. The convergence is not perfect because the form of the two pictures is slightly different. If the left picture be red, and the left eye be furnished with a green glass, this eye will see the picture in black on a green background; the right eye furnished with a red glass will see the right picture (green) in black on a red background, so that the resulting picture in relief will be black on a white or greyish ground. It is evident that this instrument can only be used for drawings or printed pictures. It is interesting to notice that in using this stereoscope, the optical axes of the eyes converge naturally, as in ordinary sight, because the pictures are superposed. We shall allude further on to stereoscopes of projection—one of which has furnished the principle of the preceding apparatus —and which also permit this natural convergence.

Stereoscopes for a Single Picture.—We shall here describe those instruments which are more rightly "stereoscopic curiosities," than

stereoscopes properly so called; for they are constructed for the purpose of giving stereoscopic relief, by using only one picture; and it is very evident that this is nonsense. Their use, however, is very restricted, and any sort of picture cannot be examined by them. However, the following is the artifice employed:—

We will suppose an object C, seen from the front, whose two halves are symmetrical, in

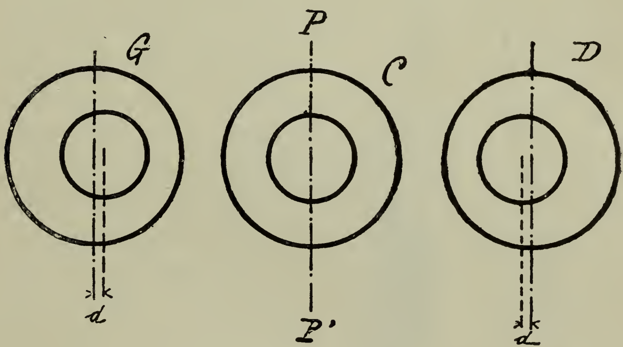


Fig. 50.

accordance with a vertical plane PP' (Fig. 50) (in the present case it is the end of a pencil seen flat). The right and left pictures of this object are alike; but, if, while looking at two points situated in the plane PP' from two different distances (for instances, the centres of the two bases), one of them be diverted, in accordance with the other, to a distance *d* in the left picture

G, the same point in the right picture D would also be diverted to the same distance, but in the opposite direction. The same thing would happen to all the similar points in the two pictures; in other words, the right and left pictures are symmetrical in accordance with the line of intersection of the plane PP' with the plane of the pictures. (It is evident that this symmetry only exists in the forms, and not in the shadows of the objects). The first and second pictures seen in a mirror would be alike.

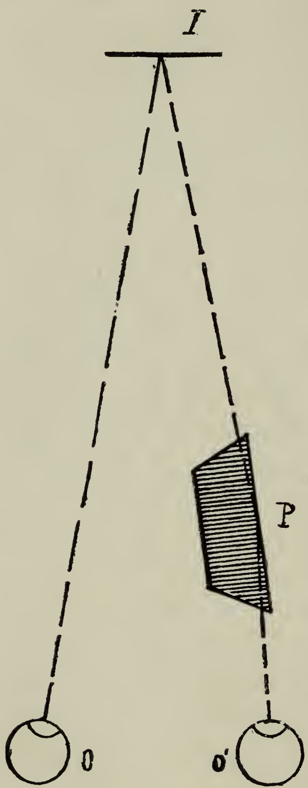


Fig. 51.

Brewster based on this idea, a stereoscope for a single picture. Fig. 51 suffices to show the way in which it is disposed. I is the single picture seen directly by the left eye, and P is a

prism of total reflection, intended to give the exact picture seen by the right eye. By slightly inclining the prism P convergence is easily produced. The picture seen through the prism is rather smaller than the other, because of the difference in the distance, but it is so slight that it

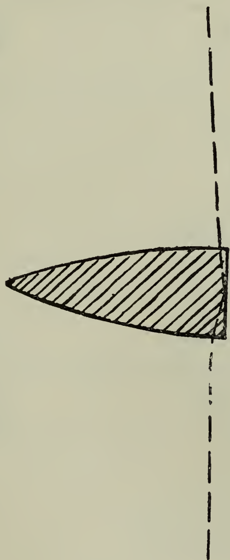


Fig. 52.

does not spoil the stereoscopic effect. Brewster, however, proposed to correct this by the use of a lens, or, still better, by enlarging the two pictures by using two lenses of rather different focus. He also proposed to use, in place of a prism, the half of a bi-convex lens (Fig. 52), the other half being

employed for enlarging the picture seen directly.

It is extremely easy to repeat this experiment for the perception of relief by a single picture. We give (Fig. 53) the left picture of a symmetrical object; the reader can, by using a single total reflection prism, held in the hand before the right

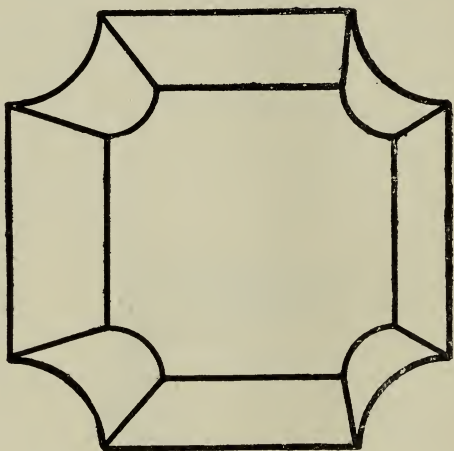


Fig. 53.

eye, obtain relief in this picture. It will be noticed that in refracting the right picture to separate it from the left, it is rather weaker than the left; this is due to the absorption of light by the prism; but its only inconvenience is the very slight diminution of intensity in the resulting picture.

PANORAMIC STEREOSCOPES. VARIOUS COMBINATIONS.

DUBOSCQ invented two stereoscopes for the examination of pictures of great length, such as panoramic views.

The first of these instruments (Fig. 54) is composed of two mirrors M M', whose positions can be regulated so that they will reflect the photographs (placed A and E one above another) in two frames B B', before which the eyes are brought. Thus, in this instrument the pictures are seen on the surface opposite to the observer. Unlike other stereoscopes, the dimensions of the pictures are limited in height, but not in length.

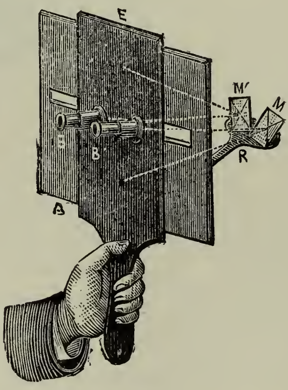


Fig. 54.

The plan of a second apparatus is shown in Fig. 55. The pictures face the observer; one of

them is looked at directly by the right eye; the other is seen by the left eye through two total reflection prisms, one of which is movable for the purpose of exact regulation.

The first of these stereoscopes has been combined with the phénakisticope in the following manner: A hollow vertical cylinder holds the two

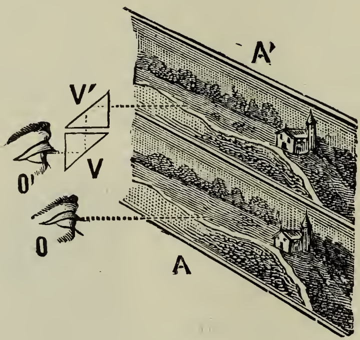


Fig. 55.

series of pictures, placed one exactly beneath the other. The cylinder is pierced with holes, corresponding to the frames fixed on the exterior. The mirrors are placed inside. Duboscq named this instrument the *stereophantascope* or the *bioscope*.

In 1860, Czugafewicz invented a stereoscope with lenses so placed that the pictures could pass rapidly before them, and thus form a phénakisticope.

The stereoscope and the heliochromoscope can also be combined. As is generally known,

the latter instrument was invented by Mr. F. E. Ives, to show photographs in colours, by the superposition of three pictures of different colours. It seems very easy then to join stereoscopically two heliochromoscopes, and thus obtain, at the same time, both colour and relief.

THE EXAMINATION OF STEREOSCOPIC PICTURES WITHOUT A STEREOSCOPE.

SEVERAL of the stereoscopes already described can be so simplified that anyone can make them.

Thus that of Eliott & Waterston, and the one invented by Volpicelli can be made of a simple wooden or cardboard box. Wheatstone's stereoscope can also be made without great expense.

A stereoscope with a single prism can be made by fixing two sheets of glass having a surface of several square centimètres one on the other with a little modelling wax, and by introducing between them some drops of water to form a liquid prism.

There is, however, a much simpler way of examining stereographs mounted in the ordinary way. It is by looking at the pictures directly, without the interposition of any instrument whatever.

We have seen that in natural vision the eyes looking at an object placed at the minimum of distinct vision converge at an angle of about 15 degrees. In order to make each eye look at a separate object an artificial squinting must be forced, and that can be done without much difficulty after a few hours' practice. But, as at first the attempt results in great fatigue to the visual mechanism, it is better not to prolong it beyond a quarter of an hour each day.

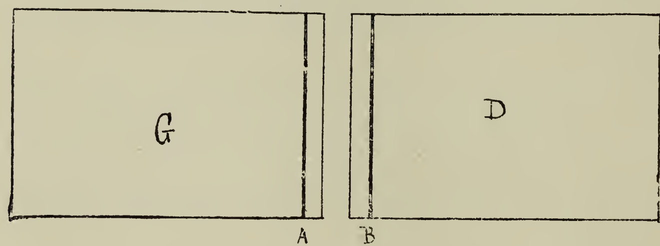


Fig. 56.

The course of procedure is as follows:—

Take two cards, G and D (two visiting cards would serve the purpose), and draw on the edge of each card a line, A B. Then, holding a card in each hand, bring them near together, as in Fig. 56, so that the lines shall be only a few millimètres apart. Two lines will then be seen by first of all fixing an object a little further away so as to produce voluntary convergence. Under these conditions superposition will be produced without

much effort, or to be more exact, three lines will be seen, each eye seeing two, the middle one being formed by the convergence of the other two. This experiment must be repeated several times, until superposition is obtained without difficulty. The two cards must then be separated by degrees, so as to accustom the eyes to a more and more feeble convergence, and so on until a separation of several centimètres has been attained. The two lines must then be replaced by two simple designs (for instance, the printed side of the visiting cards), and it will be found that convergence is easily obtained. Finally, take two stereoscopic pictures and cover one with the other, so as to place two similar points at the same distance, as in the previous experiment. The relief will appear at once, and the experiment must be continued by gradually separating the prints until the normal distance has been reached.

It will be seen that if the prints are separated too quickly the eyes will immediately relapse to their normal convergence ; this would not matter very much, as the relief could be easily found again by slightly approaching the two pictures.

This experiment illustrates in a striking manner the difference between stereoscopic and ordinary pictures. At each side of the central picture seen in splendid relief, the two flat pictures will readily be observed.

We must remark that in spite of the fatigue at first experienced, this way of looking at stereoscopic pictures entails no very abnormal effort on the muscles of the eyes, if the separation of the two prints be not greater than that of the eyes.

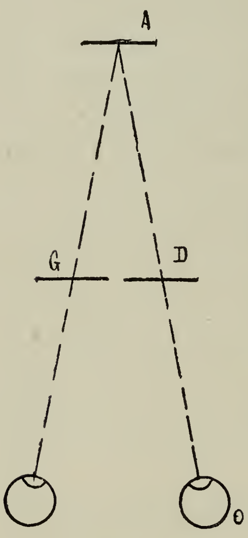


Fig. 57.

In looking at an object a long way off—a star, for instance—the eyes would be looking in parallel lines. If the conditions differ from ordinary vision to such an extent as to require a previous apprenticeship, it is, that each time that we look at an object placed at a short distance, at the same time that natural convergence is produced the crystalline lens accommodates itself instinctively to that distance. The two effects — convergence and accommodation—being connected, if the eyes converge as if they were looking at an object at the distance O A, a little difficulty will be at first experienced in making them accommodate themselves to the distance O D.

To look at prints without a stereoscope, Faye (1856) suggested the following method:—Take

a sheet of paper in which two holes, 5 millimètres in diameter, are pierced at about the same distance as that of the eyes. Hold the sheet in one hand, and the picture in the other; by degrees place the eyes to the sheet of paper, without ceasing to look through the holes. Soon the two holes will seem

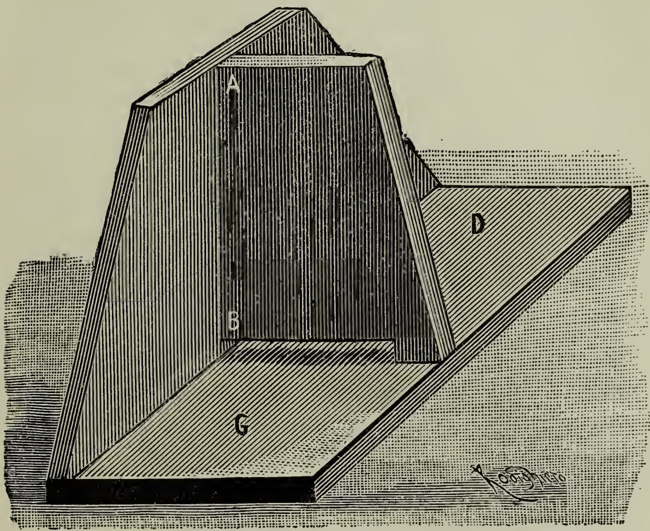


Fig. 58.

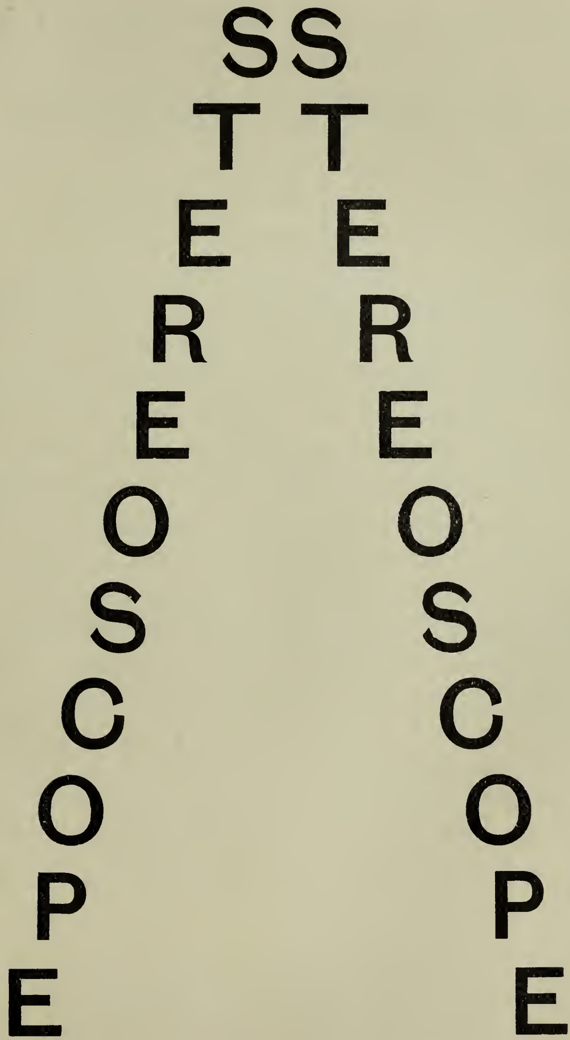
to merge into one, and the picture in relief will then appear between the two flat pictures.

Frick constructed for the same purpose the little instrument shown in Fig. 58. The prints are placed on G and D. The partition A B separates the two pictures, and prevents the sight of the flat

ones on each side of the one in relief. The height A B corresponds to the minimum distance of distinct vision.

Stereoscopic prints can, on the other hand, be examined by exaggerating the convergence of the eyes instead of diminishing it. The right picture must then be placed on the left, and *vice versa*. We shall not describe in detail this method of procedure, of which we have already spoken in connection with the stereoscopes of Eliott and Waterston and of Volpicelli. These instruments are by no means necessary for obtaining relief, and their only purpose is to relieve the observer of the embarrassment of seeing the two flat pictures at the same time as the one in relief. The second has the advantage over the first of allowing the use of pictures of larger dimensions; on the other hand, it is not adapted for the use of prints mounted on cards as for the ordinary stereoscopes, because it necessitates the transposition of the prints.

Those of our readers who wish to try the experiment of looking at stereoscopic pictures may make use of the diagram on opposite page. It consists of a series of similar letters, with constantly increasing distances. First try to superpose the two Ss, then the two Ts, etc. When the two Es at the base, whose separation is about the same as that of the eyes, can be superposed, an ordinary stereo-


STEREOSCOPE
STEREOSCOPE

graph can be examined without apparatus. We have stopped the table at the separation of the eyes, but, with practice, it is possible to go beyond. The optical angle then becomes negative, that is to say, the two visual axes appears to be behind the head; but the sensation of relief and also that of distance can be equally perceived in the same way.

When a stereoscopic picture is examined either by the naked eye, or by any of the above methods, or by means of a stereoscope, it is only possible to see at the same time a very small part of the print, and the optical angle has to be changed, when carrying the sight from one point to another, as in looking at a solid object. The reason is simple—two identical points *b b*, in the foreground of a sketch (Fig. 17) are at a shorter distance apart than *a a*, in the background. The optical angle must, therefore, be diminished, when the sight is carried from point *a* to point *b*.

STEREOSCOPES OF PROJECTION.

STEREOSCOPES of projection are constructed for the purpose of allowing several persons to examine the same stereograph, so magnified that all its details may be seen at a distance.

Three kinds of instruments have been constructed of the above class up to the present. They are as follows* :—

1st. Stereoscopes for coloured pictures ;

2nd. Eclipse stereoscopes ;

3rd. Stereoscopes for use with polarised light.

None of these instruments come into practical consideration, though most of them—and especially the eclipse stereoscopes—give admirable effects ; but for such an apparatus to completely accomplish its purpose, it should be easy of manipulation, so that the pictures can be rapidly changed ;

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* Duboscq proposed the use of total reflection stereoscopes for examining pictures projected by a lantern. We simply mention this application, without describing it.

the instrument put into the hands of the spectator should not be very costly; and finally, no previous practice should be needed for the projections to be properly seen. It may be granted that the last condition is almost fulfilled, because the various instruments we are about to describe project the two pictures over each other, so that the eyes in looking at them converge as if they were looking at any ordinary object, and accommodate themselves to the distance corresponding to the convergence. The eyes, therefore, need make no abnormal effort.

Before describing these numerous stereoscopes, we will say something of the instrument which Claudet (1858) named the *stereomonoscope*, which utilises two pictures thrown on a screen, but which can only be used by one person.

The two pictures right and left, thrown by two lanterns, are received on a screen of ground glass, to be viewed as transparencies. The position of the two lanterns is regulated so that the pictures may superpose each other as exactly as possible; under these conditions, by standing before the picture (which appears single) and at a short distance from it, the stereoscopic relief will be perceived. The reason is that each eye does not see the two pictures with the same intensity; but we shall allude to similar cases in another chapter.

STEREOSCOPES FOR COLOURED PICTURES.—By the aid of two lanterns, two pictures are thrown on to the same screen, so that they superpose each other. A red glass is then placed before the condensor of one of the lanterns, and a green glass in front of that of the other. Each of the pictures thus takes a particular colour, but on the screen it is impossible to distinguish them by ordinary sight; besides, the superposition not being always perfect, the mingled picture is rather grey and not very distinct.

If looked at through green and red glasses, each of these glasses only allows the corresponding colour to penetrate, and each eye sees only one picture. Red and green being complementary colours, the resulting impression is a black and white picture seen in relief. In practice, it is very difficult to get a picture whose white parts are really pure, the glasses not allowing the rays to pass as absolute monochromes, and the two tints not being exactly complementary.

For the experiment to be satisfactory, two powerful lights must be used, because of the great absorption produced by the coloured glasses.

This method was mentioned by Rollman in 1853, and was rediscovered by D'Almeida, who, we believe, constructed the instrument for the first time in 1858.

Eclipse Stereoscopes. — The principle of these instruments is due to D'Almeida (1858), and may be described in a few words :—

Let us suppose that two optical lanterns L L' are placed and regulated so as to project on the same screen E (fig. 59) two pictures, right and left superposed, and that a shutter R turning

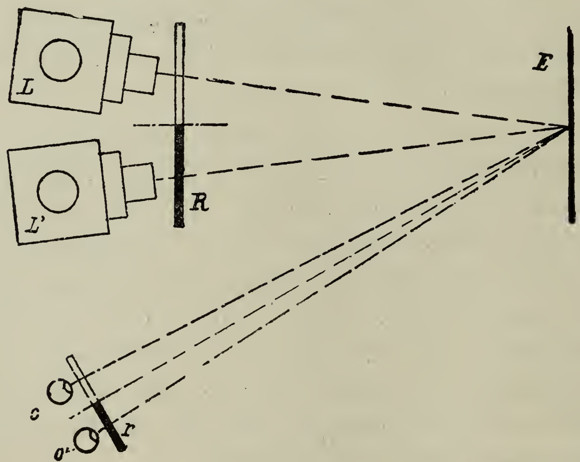

Fig. 59.

rapidly before the two object glasses uncovers them successively.

An observer looking at the screen will only see one picture without relief, formed in reality of a succession of right and left pictures. But if before the eyes O O', a shutter *r* turns with the same rapidity and simultaneously as the first R,

the left eye will be uncovered each time that the left picture is thrown on the screen, and the right eye each time that the right picture is projected. Each eye can thus only see its corresponding picture.

D'Almeida invented a stereoscope of this kind, in which the two shutters R and *r* were

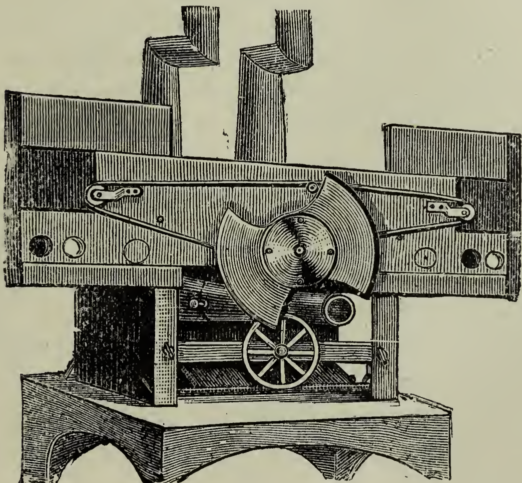

Fig. 60.

mechanically connected. He also suggested the use of electro magnets for obtaining the synchronism.

A. Stroh presented to the Royal Society of London, in 1886, an eclipse stereoscope which is represented by figure 60.

The two lanterns are mounted side by side on one stand, which also holds the shutters. This instrument was made for two persons, but it could evidently be made for a greater number. The same mechanism, which actuates the shutters of the lantern, also move the ocular lids, mounted to the right and left of the lantern. The speed of rotation should be so great that the picture is continuous: for each eye from 30 to 40 flashes a second should be reckoned. As the discs used in Stroh's instrument produce two flashes each turn, their speed should be about 15 to 20 turns a second.

We show below in detail, the form of the shutters, which should be so fixed that only one picture will be projected at once. The openings are cut in sections whose angle is a.

If β be the angle formed by the extreme edges of the lenses (or of the holes) to be uncovered and α be the angle formed by two lines crossing the centres of these lenses, the part opened by the lid should be

$$a = \alpha - \beta$$

and the part closed

$$b = \alpha + \beta$$

and as the entire disc forms two lids

$$a + b = 2\ \alpha = 180^\circ$$

therefore

$$\alpha = 90^\circ.$$

a condition easily secured in putting the apparatus together.

In these kinds of stereoscopes, the eyes look directly at the picture, without the interposition of any prism or lens whatever. It is interesting to

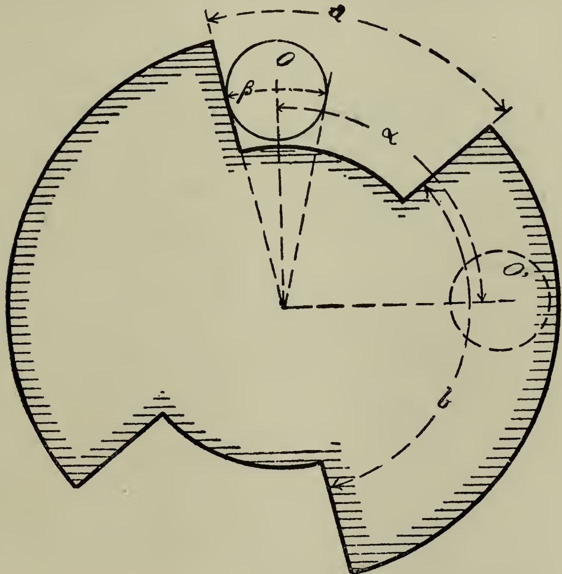

Fig. 61.

notice that relief is produced, though the two pictures are not seen at the same time.

STEREOSCOPE FOR POLARISED LIGHT.—This stereoscope was invented by Mr. John Anderson.

Two lanterns LL' project, as before, the two superposed pictures on one screen. Before each lantern a polariser PP' is introduced at a distance of 90° apart (in Mr. Anderson's apparatus these polarisers are made of blocks of glass).

The picture received by the screen and appearing single, is thus formed of two polarised

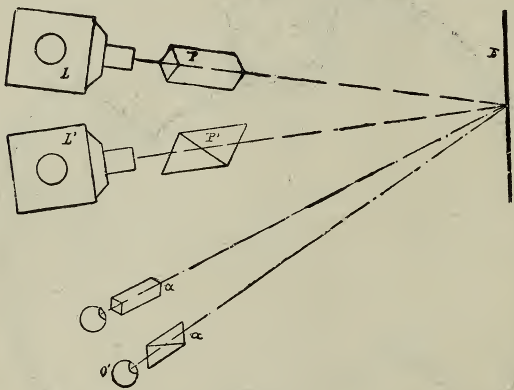

Fig. 62.

pictures, for instance one in a vertical, and the other in a horizontal position.

If an observer look at this picture through two analysers *a a'* placed before his eyes O O' and conveniently fixed, each eye will see a different picture in perfect stereoscopic relief.

The analyser is formed of two nicols prisms mounted in a sort of opera-glass. Naturally, if

the nicols be 90° from their normal position, the right eye will see the left picture, and the left eye the right picture, in such a way that pseudoscopic relief will be produced.

OBTAINING RELIEF BY A SINGLE PICTURE.

THE fact that a single picture drawn, painted, or photographed can give in different degrees the sensation of relief, has suggested the idea that it is possible to obtain a stereoscopic effect with one picture; but it has been perfectly demonstrated that complete relief, as furnished by the stereoscope can only be secured by the two eyes looking at *different* pictures.

There is one case where the picture, appearing single, can be seen in relief; but a closer examination of it, shows that it ought to be placed in the category of ordinary stereoscopic phenomena.

In looking at an image on the ground glass of a camera it appears to be in relief. H. de la Blanchère made a series of experiments on this subject and demonstrated by the following deductions, that relief is due in reality to two pictures, furnished by the two edges of the object-

glass, and that these pictures are received separately on each eye :

1st. If one eye be closed, the stereoscopic effect disappears ;

2nd. If the picture be looked at through a pseudoscope, the relief is reversed, as if the object itself were being operated on ;

3rd. If the lens be well stopped down the picture will appear flat, but the relief will remain if the diaphragm has two holes pierced on the two extremities of its diameter, horizontal to the lens ;

4th. If a blue glass be placed before one of the openings of the diaphragm, pierced in this way, and a yellow glass before the other one, by closing the eyes alternately, first a picture in the one colour and then in the other will be seen.

It is easily explained how two pictures thrown *at a different angle* on to the same ground glass, can be seen separately by each eye. The intensity of the light diffused by the ground glass, decreases very rapidly, in accordance with its separation from the direction of the incident ray. (Thus, if a wide angle lens be employed it is necessary, in order to see the picture at the edge of the focussing screen, to look in the direction of the objective ; in looking normally at the glass the picture will appear very feeble). It is then understood that the rays emanating in the direction L'O will be scarcely visible to the eye O', while it will see the

rays emanating in the direction L O'. Oiled or waxed paper presents under this condition the same properties as ground glass, but ordinary paper does not bring about the same effects, the intensity of the light diffused varying less rapidly than the angle of incidence.

Claudet based on this same principle his stereomonoscope, which we have already mentioned (page 82).

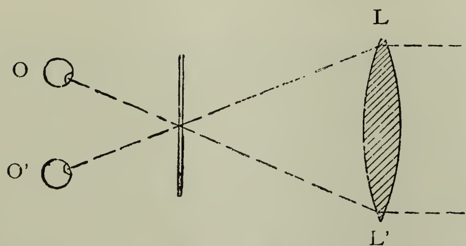

Fig. 63.

It is possible for the same effect to take place to a certain point when examining on a polished glass, transparencies taken by a lens with a large aperture, and for traces to be found in prints; which would explain why the pictures proceeding from lenses with large openings present more relief than those obtained by the same lens stopped down.* But there are also other reasons for it.

* Gaudin (1851) and Norman (1855) proposed for obtaining prints in monocular relief, the use of a lens furnished with a diaphragm pierced by two holes 65 millimètres apart.

In reality, we know that the sensation of relief is not only furnished by the perception of two dissimilar pictures, but that the proportions of different parts of these pictures also contribute to it. Thus the perspective of a picture plays a very important part. A landscape with a foreground will appear more in relief than if it only contained subjects placed at a great distance.

The relative distinctness of different perspectives also influences the apparent relief. The eye, in fact, only sees distinctly one perspective; and if a picture where the background is as distinct as the foreground (which is the case when obtained by a small opening) be presented to it, the whole will appear flat and uniform. Portrait photographers are always careful to bring their model forward, and to choose rather a light background. The perspective obtained with a wide angle lens is always more pronounced than that obtained with an ordinary one. This will be understood by examining Fig. 64, where A B, C D, represent two objects (supposed to be of the same size) placed in two different planes. The ratio $\frac{ab}{ad} = \frac{\mathrm{OC}}{\mathrm{OA}}$ of the sizes of these two objects is nearer to similarity as given by the lens O, than by O', of which the angle is greater. It follows, therefore, that the perspective can be augmented

by the use of objectives of greater angles. There is, at the same time, a limit, which is, however, mentioned only in the artistic sense. It occasionally happens that with an ordinary rectilinear lens the admitted limit of perspective is passed, though the angle seen by this lens is much less than that of the eye.

Landscape painters, however, are not in perfect accord on the question of the angle a

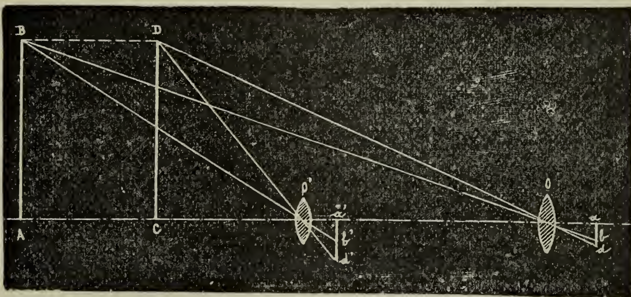

Fig. 64.

picture ought to embrace; and the distances of the eye from the object vary from 0·5 to 3 times the greatest dimensions of that object. F. Bossuet, who has studied the proportions of a great number of pictures by great masters, advises that it should be kept between 1 and 3 times. There are, however, few pictures where the distance is three times the height, and there is scarcely one where it is *more* than that.

When a photograph is examined through a magnifying glass, it is generally found that the relief is accentuated. We consider that this effect is most obvious when the picture is isolated from surrounding objects, so that the presence of these objects can only serve as data to determine the perspective of the picture. A similar result can be obtained by isolating the picture with a cardboard diaphragm having an opening of the same shape as the picture, and which is interposed at a short distance from the photograph (of course, looking at it with only one eye).

Eye glasses or single glasses (often wrongly named monostereoscopes) have been made for the examination of ordinary photographs.

We have already mentioned that similar effects can be secured by an iconoscope. It is strange that it should have been proposed (V. Eckhont, 1857) to use one sort of telestereoscope to get at the same result! We must draw attention to the fact that in these various instruments the form of the box limits the luminous rays, and therefore isolates the picture or photograph. Almost the same effect is realised by the use of opera glasses, or, more simply, by using two copper or cardboard tubes.

It is evident that the result obtained by all these methods has nothing in common with stereoscopic relief. The reason we have described

or alluded to them is because on one hand, the attempt to obtain "monocular relief" has often been made, and on the other hand, because these different effects take place in the stereoscope itself, diminishing or increasing relief.

APPLICATIONS
OF THE STEREOSCOPE.

THE first stereoscopes were intended for the examination of drawings made by hand and reproduced by lithography; but these drawings could only be obtained by means of a geometrical tracing, a long and very troublesome operation when the objects were of a complicated nature. Besides, only a small number could be found, which represented relatively simple subjects, such as geometrical figures, crystals, and architectural details.

In 1845 Wheatstone conceived the idea of using Daguerreotypes in his stereoscope. This was the turning-point in the more important applications to which the stereoscope owes its position since 1850. It is curious to note that although the stereoscope was an English invention the French makers were the first to recognise its possibilities, to show the way in which it might be useful to artists, and to succeed in making a very incredulous public understand that photography

was incomplete without it. These makers had, moreover, the satisfaction of seeing their ideas shortly put into practice in England itself.

Since the rapid processes of photo-mechanical impression have permitted photographs to be sold at very low prices, it would have been thought that the stereoscope would have increased very materially in public favour. It is only recently that it has done so to any considerable extent, but its popularity has not grown in proportion to the facilities offered for enjoying its wonders. The photographic magazines are continually lamenting the fact, and lay the blame on the less conscientious photographers who supply to the trade so-called stereoscopic photographs which are, in reality, formed of two prints of the same picture. In our opinion the fault is rather in the stereoscopes themselves, which are generally lenticular instruments of fixed focus and of the same separation, *i.e.*, they are only adapted to one sight. For one person who can use them with advantage, there are ten who will see two pictures, and who therefore think "when I close one eye I can see much better." It is therefore very necessary to have a stereoscope exactly adapted to the sight, or better still, one which can be adapted to all sights.

In our opinion stereoscopic relief forms one of the most beautiful phenomena of natural philosophy. It is impossible not to be filled with

admiration on first using the stereoscope. But apart from mere curiosity, it possesses another attraction: all that nature and art can offer for the enjoyment of the eye the stereoscope can, almost to colour, present with irreproachable fidelity.

On a stereoscopic print the artist finds clearly written very valuable information. Instantaneous pictures in particular, are to him very precious documents.

Landscapes, portraits, and figure studies become more realistic, more true to nature by use of the stereoscope.

We have seen a catalogue of machinery, illustrated stereoscopically, and this application might with advantage be more extended than it is. In fact, by no other process can the exterior aspect of an object be so clearly shown.

Apart from these direct applications, there are several special uses to which the stereoscope may be put.

In order to measure strabism (squinting), Javal used a hinged reflecting stereoscope (Fig. 65) constructed in the following manner: The two mirrors, G G', are united by a hinge, C C', and a divided semicircle fixed on C is used for measuring the angle made by them. A A' are two tablets fixed to the mirrors, and forming with them an angle of 45°. On each tablet there is a

mark, P. When these two marks superpose each other stereoscopically, the angle of the two visual rays can be found by simply looking at the semicircle, C.

Dove* (1859) discovered that each time two slightly dissimilar pictures are examined by a stereoscope certain parts appear in relief. If two

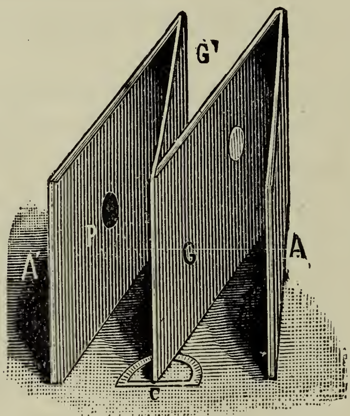

Fig. 65.

medals, struck from the same mould but in two different metals, be placed in the stereoscope, the

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* Dove, *Ueber Amwendung des Stereoskops um einen Druck von seinem Nachdruck, überhaupt ein Original von seiner Copie zu unterscheiden.*

Monatsberichte der K., Preuss. Akademie der Wissenschaften zu Berlin, 1859. P. 280-288.

Poggendorf Annalen, CVI., 1859. P. 657-660.

resulting picture will appear convex, because after the stroke of the beam, the two metals are unequally distended. Two medals, one of silver and the other of bronze, will give this idea very distinctly.

In the same way, if the same sentence be set up twice in type, and the proof be put into the the stereoscope, certain letters will appear to be detached from the others, and go before or behind. The reason is that the letters have not exactly the same space in the two proofs. The same effect would not be produced if the two phrases were printed twice from the same composition; it is possible, however, in this case, for the whole to appear convex or oblique, on account of the unequal contraction of the paper. In this way a true bank-note may be distinguished from a forged one, or even two notes struck from two different plates, or two different editions of the same text. The equality of the divisions of a graduated scale may also be verified: it is only necessary to obtain stereoscopic pictures of two parts of it.

We do not see why stereoscopic prints should not be used for the purpose of decoration, like ordinary photographs, and why they should not also have the honour of a frame. Duboscq has already used them for ornamenting a lamp shade; there should be a great number of similar ways of making use of them.

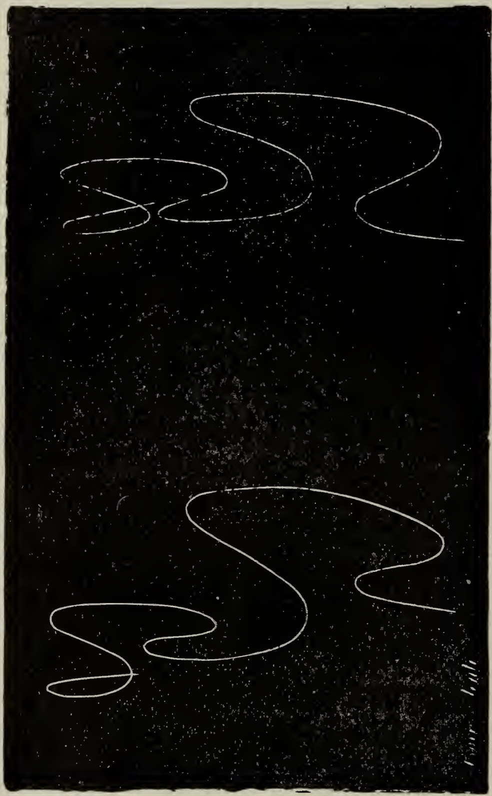

Fig. 66.

Fig. 67.

Finally, the stereoscope might become a valuable auxiliary of information, by facilitating the study of solid geometry, of analytic and descriptive geometry, and even of mineralogy and natural philosophy.

Lissajous (1856) made a very curious application of it. The remarkable works of this learned man on the optical study of vibrating movements are well known. He showed that the even curve obtained by the composition of two rectangular vibrations, whose periods are in the proportion of two entire numbers, can be considered in the same way as the projection of a figure traced on a cylinder*, on a plane passing through the axis of the cylinder.

Hence the different figures which correspond to the various different phases can be seen by the observer in moving round the cylinder, keeping his eye all the time at the level of the mean circumference. Two of these figures, taken at an angle† of from 10 to 12 degrees apart, and placed

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* This figure would be engendered by a point, turning with a uniform movement round the cylinder, at the same time that it oscillates according to the law of pendulums, from one part to another of the circumference traced on the cylinder.

† This angle represents precisely the difference of phase.

in the stereoscope, give a resulting picture which is the generating curve.

Marey (1885) in his studies of locomotion, made a remarkable application of stereoscopic photography, in order to register the movement described by one part of the body in walking or running. A man dressed in black, and carrying a bright light at the height of the sacrum, walks

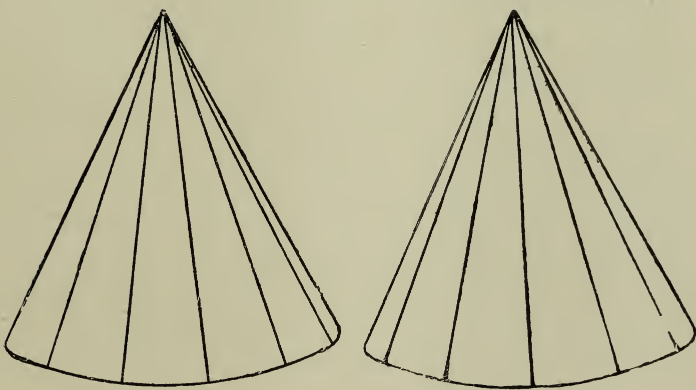

Fig. 68.

on level ground in front of the stereoscopic camera. The two prints obtained (Figs. 66 and 67) examined in the stereoscope, reproduce in the form of a curve in space the trajectory described by the point of a pencil. The same author has analysed in the same way the actions of a horse, the motions of the body of a bird, etc.

Stereoscopic Pictures by Drawing.—The use of stereoscopic pictures drawn by hand (Fig. 68) has been almost abandoned; their execution is, in fact, too troublesome, and they do not always give correct effect, because of the difficulty experienced in shading them properly. It is also almost impossible to draw anything but objects of well-defined geometrical form; the proper execution of a landscape or portrait may be looked upon as impracticable.

STEREOSCOPIC PHOTOGRAPHY.

IT is quite probable that without photography the stereoscope would have been almost unknown outside the physics laboratory; as the sensitive plate alone can furnish perfect stereoscopic pictures, exact not only stereoscopically, but in perspective and light and shade.

Two cameras placed at a small distance from each other can, in fact, look at an object as the two eyes do. We shall now examine in detail the conditions necessary to produce by photography the same effect as that given by a direct view of the object itself; in other words, how far apart the lenses of the two cameras should be, to secure exact relief.

On this point authorities on stereoscopic matters have expressed radically different opinions, some saying that the distance should be that of the eyes; others, that the optical angle should be the same as that made by the eyes, in looking at a picture in a stereoscope; others again, assigning intermediate distances between these two extremes.

The discord, however, is only apparent; a stereograph is an artistic work, in which judgment and taste ought to have precedence before calculation; but the conditions of the desired relief once determined upon, it is no longer possible to hesitate over the separation of the lenses.

Suppose that an observer standing before a landscape desires to have a stereoscopic picture of it *with the same relief* seen in nature; it is very evident that the optical angle of the eyes, and that of the lenses should be the same, and therefore, that the lenses should be placed as far apart as the eyes are.* If the landscape be at a great distance, relief will be extremely feeble, perhaps imperceptible, but it will be exact.

Relief may be increased; and to make it as pronounced as possible, it would be necessary to suppose the landscape reduced to a small scale, *and placed at the minimum of distinct vision.*

To obtain two photographs which correspond in this case, the lenses must be separated, until the angle of convergence is equal to the optical angle.

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* To avoid bringing perspective into the question, we are supposing that each lens is fixed at about the same angle as the eye.

At the same time it is desirable to take into consideration the latitude afforded by the range of the eyes.

M. Cazes has, in fact, noticed that in looking at the different planes of an object, the optical angle and the focus of the eyes change at the same time, while in looking at a picture in the stereoscope, the optical angle alone changes when the sight is carried from one plane to another. In order, then, to preserve the natural conditions, the photographs must be viewed at such a distance that the eye can see all the planes at the same time, without the necessity of varying the focus.

M. Cazes admits that for a normal sight, at the distance v, two planes can be seen with the same adjustment at a distance $\frac{v}{10}$, so that if f be the united focus of the lens (the distance from the ground glass to the nodal points behind) and d the depth of the object, the *minimum* distance D from the lens to an average perspective of the object will be

$$D = \frac{10fd}{v}$$

and the separation of the lenses must be chosen to correspond with the optical angle, probably 12 to 15 degrees.

If we reckon for v the value of 20 centimètres we have the following result :

$$\frac{D}{d} = \frac{f}{2}$$

That is to say, for an object glass of 10 centimètres (four inches) focus, the distance of the object should be equal to, at least, five times its depth.*

The most perfect relief is obtained by this method; very vivid, but not exaggerated. At the same time its use is very limited, for on the one hand, the distance between the object-glass and the subject can rarely be measured; and on the other, it is often difficult to find two convenient points whose distance would correspond to the optical angle. Finally, it is more difficult still to assume a position at the distance D, indicated by the formula. It is seldom that a landscape can be photographed conveniently at

* It is sometimes astonishing how much this method takes into account the distance v and also the stereoscope used. It is a fact, however, that relief depends on it. It may be accounted for by looking at the same stereograph at various distances, by one of the methods already mentioned (page 73). It will be easily found that relief is augmented when the distance between the eye and the print is greater. When a magnifying stereoscope is used, it is necessary to take for v, the distance at which the print would be from the eye, if it were seen directly and of the same size.

two different distances, and when once the photographer has found a point to suit him, he ought to be able to make his picture from there.*

At the same time this method, which can only be applied precisely in the case of detached objects (objects of art, crystals, etc.), furnishes some useful points when views of any kind are in question. Suppose that the desired position is too feeble by half according to the above formula; the optical angle must be divided by two, and by bringing the lenses thus together the same correspondence will be found which ought to have been obtained by placing them twice as far apart with the normal angle.

It is quite clear that it is by no means necessary for securing stereoscopic relief, to place the camera at exactly the desired distance: exaggeration of relief must be guarded against, and when there is a doubt it is better to diminish the angle than to augment it. But for all ordinary stereoscopic operations it is sufficient to *estimate* distances.

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* Practically, for a given lens, the distance D is determined by the size desired for the picture. Therefore the most frequent problem is, not to find the distance D, which corresponds with the maximum separation of the positions, but to find the separation corresponding to a given distance.

But to sum up, the following are the principles to be followed with regard to the separation of the lenses.

Calculate by the formula of M. Cazes given on page 111 *the distance at which the camera should be fixed, and if the place, or the focus of the lenses prevent operating at that distance, bring the lenses together, so as to diminish the angle in the same proportion.*

Never exaggerate the separation; rather be under than over the calculation.

In some cases the manner of proceeding which we have mentioned would be of no use whatever. Thus in photographing a panoramic view, or a landscape extending beyond the sight, a great mistake would be made if the depth were estimated. In such a case it would be better to approximate, after a proper trial, the angle to be given to the two lenses. The eye is satisfied with a stereoscopic picture, whatever its relief may be within very extended limits, always provided it be not exaggerated. The best proof of this is, that most photographers take landscapes exclusively with lenses of a fixed separation.

We give a table showing to 16° the separations which correspond to the different angles.

Distance of the Subject (mètres).	SEPARATION (IN METRES) OF THE OBJECT-GLASSES, FOR THE ANGLES OF							
	2 Degrees.	4 Degrees.	6 Degrees.	8 Degrees.	10 Degrees.	12 Degrees	14 Degrees.	16 Degrees.
1	0,0350	0,0698	0,1040	0,1398	0,1750	0,2102	0,2456	0,2810
2	0,0700	0,1396	0,2096	0,2796	0,3500	0,4204	0,4912	0,5620
3	0,1050	0,2094	0,3144	0,4194	0,5250	0,6306	0,7368	0,8430
4	0,1400	0,2792	0,4192	0,5592	0,7000	0,8408	0,9824	1,1240
5	0,1750	0,3490	0,5240	0,6990	0,8750	1,0510	1,2275	1,4050
6	0,2100	0,4188	0,6288	0,8388	1,0500	1,2612	1,4736	1,6860
7	0,2450	0,4886	0,7336	0,9786	1,2250	1,4714	1,7192	1,9670
8	0,2800	0,5584	0,9184	1,1184	1,4000	1,6816	1,9648	2,2480
9	0,3150	0,6282	0,9432	1,2582	1,5750	1,8918	2,2104	2,5290
10	0,350	0,698	1,048	1,398	1,750	2,102	2,456	2,810
15	0,425	1,047	1,572	2,097	2,625	3,153	3,684	4,215
20	0,700	1,396	2,096	2,796	3,500	4,204	4,912	5,620
30	1,050	2,094	3,144	4,194	5,250	6,306	7,368	8,430
50	1,750	3,490	5,240	6,990	8,750	10,510	12,275	14,050
75	2,625	5,235	7,860	10,485	13,125	15,255	18,412	21,075
100	3,50	6,98	10,48	13,98	17,50	21,02	24,56	28,10
200	7,00	13,96	20,96	27,96	35,00	42,04	49,12	56,20
300	10,50	20,94	31,44	41,94	52,50	63,06	73,68	84,30
400	14,00	27,92	41,92	55,92	70,00	84,08	98,24	112,40
500	17,50	34,90	52,40	69,90	87,50	105,10	122,75	140,50
600	21,00	41,88	62,88	83,88	105,	126,12	147,36	168,60
700	24,50	48,86	73,36	97,86	122,50	147,14	171,92	196,70
800	28,00	55,84	91,84	111,84	140,00	168,16	196,48	224,80
900	31,50	62,82	94,32	125,82	157,50	189,18	221,04	252,90
1000	35,00	69,80	104,80	139,80	175,00	210,20	245,60	281,00

To obtain with certainty the desired relief, we have used the following process, which is not based on calculation but on direct observation.

The two lenses being properly focussed, we examined the images on the ground glass by means of the apparatus shown in Fig. 71, as if they were actually stereoscopic prints.

This instrument is a sort of total reflection stereoscope, reduced in size as much as possible so as to occupy very little space. It consists of

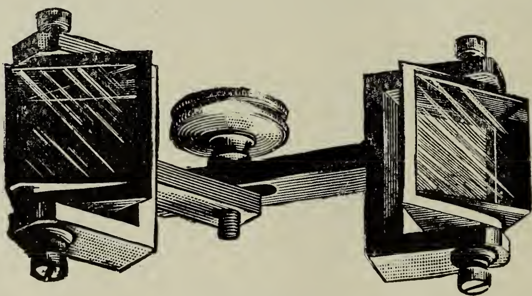


Fig. 71.

two total reflection prisms, movable in a frame-work, which also allows their separation to be varied so that they may be adapted to different sights.

It is necessary to use an instrument of reflection because the pictures ought to be reversed. The pictures seen on the ground glass are thus reversed, and the right picture will, therefore, present the

left perspective, so that in looking directly at them the pseudoscopic effect will be at once perceived.

The right picture could also be presented to the left eye, and *vice versa*. For that a stereoscope similar to the one invented by Blanchère (page 37) should be used. This instrument might also be advantageously adopted when long-focus lenses are used, because it allows the pictures to be magnified. In fact, for considerable separations, the apparatus, (fig. 71) must be used for looking at pictures at a great distance (in looking at them near at hand they are too much deformed as regards breadth, and therefore as regards inclination). In these conditions the relief of the picture is stronger than it would be at the minimum distance of distinct vision, and further, the details are less easy to grasp. Besides the methods mentioned above, which appear to us most rational, and which give good results, we shall state the principal rules given by various natural philosophers. As will be seen, these rules are far from agreeing with each other, and, with the same subject they give very different separations.

Brewster was of opinion that the distance of the lenses should not be greater than that of the eyes.

Wheatstone varied equally the optical angle and the distance, and suggested the following table. Given a distance D, corresponding to the

various values α of the optical angle (the distance of the two eyes being e, the formula

$$D = \frac{1}{2} e \, cotg \frac{1}{2} \alpha$$

gives the figures of the succeeding table).

Optical Angle.	Distances (English inches) =·254.
2°	71·5 in.
4°	35·7 ,,
6°	23·8 ,,
8°	17 8 ,,
10°	13·2 ,,
12°	11·8 ,,
14°	10 1 ,,
16°	8·8 ,,
18°	7·8 ,,
20°	7·0 ,,
22°	6·4 ,,
24°	5·8 ,,
26°	5·4 ,,
28°	5·0 ,,
30°	4·6 ,,

Sutton (1856) formulated the following rule: "The angle of convergence between the axes of the two lenses, directed towards the centre of an object, should be equal to the angle of convergence, between the axes of the eyes, directed towards the same centre, on the virtual picture seen in the stereoscope."

As we have already seen, working by this rule will give true relief with objects of slight depth, but in most cases it will be exaggerated.

Claudet* (1853) observed that "it is not necessary for the binocular angle to be greater than that which is subtended by a base of 2½ inches, when looking at the object at the nearest distance which permits all the picture to be included."

He remarked also that it is necessary to have lenses of long focus, so that the foreground is not magnified more in proportion to the distance, than is the case in natural vision.

He constructed an instrument called the *stereoscopeometer*, with which separations corresponding to various distances and angles can be rapidly found.

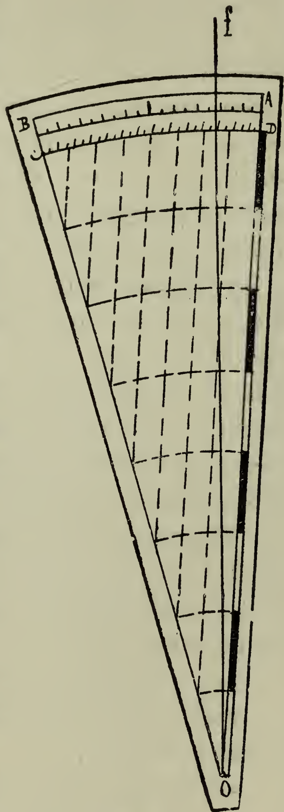


Fig. 72.

This instrument (fig. 72) is composed of a section of cardboard, 20 degrees in size, divided

* A. Claudet. *Du stéréoscope et de ses applications à la photographie.*

into degrees on the arc A B. A second arc C D indicates the corresponding separations, and the radius D O carries divisions which correspond to the distances of the object. By the points of division of this radius, arcs have been traced having the same centre as the section. At this centre is fixed a thread *f*. If the separation which, at a given distance, corresponds to an angle of 4 degrees has to be found, the thread *f* is placed facing the division 4, and it is followed to its junction with the arc corresponding to the distance given: at this point of junction is found a parallel to the radius O D, which cuts the arc C D at a point which indicates the separation sought for. A certain number of parallels to O D have been traced on the apparatus, so that it can be followed directly without pencilling.

There are various ways of obtaining a stereoscopic view of an object or landscape. According to the appliances at our disposal, the negative can be obtained:

1st. By displacing the object;

2nd. By two successive exposures with one ordinary camera;

3rd. By a single exposure with a camera having two lenses, and a partition separating the bellows into two equal halves.

STEREOSCOPIC PHOTOGRAPHY BY DISPLACING THE OBJECT.

IT is easy to understand that if, instead of taking two successive views, by moving round the object, the object itself can be moved before the fixed apparatus, the same result will be obtained.

The most beautiful application of this method has been made by Warren de la Rue, who has obtained magnificent photographs of the planets (Saturn in particular), by photographing them at such intervals of time that they had turned round the desired angle.

He also obtained photographs of the moon, by taking advantage of the movement of libration. The relief obtained is magnificent. The *maximum* libration of the moon from east to west is $15° 50'$, and therefore corresponds very nearly to the *maximum* optical angle. The libration from north to south is $15° 34'$.

The same method is applicable to photographing objects of small dimensions, easily moved, such as scientific instruments, small

pieces of machinery, etc. The object to be photographed is placed on a revolving stand (fig. 73), the base of which is divided into degrees.

When one plate is taken, the object is turned through the desired angle, and the second exposure made without moving the camera.

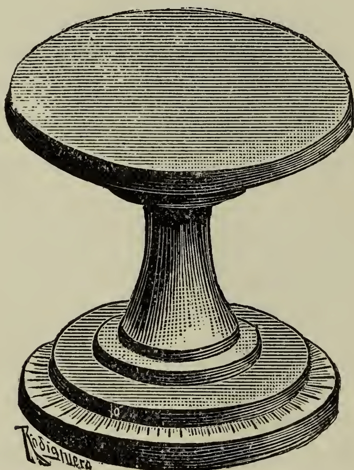


Fig. 73.

By continuing the rotation a third and fourth plate can be obtained and so on, so that each picture shall be the left in reference to the preceding one and right in reference to the one following. By moving round the entire circumference, 10 degrees each time, 36 plates may be taken, which will give views of the object under all its aspects.

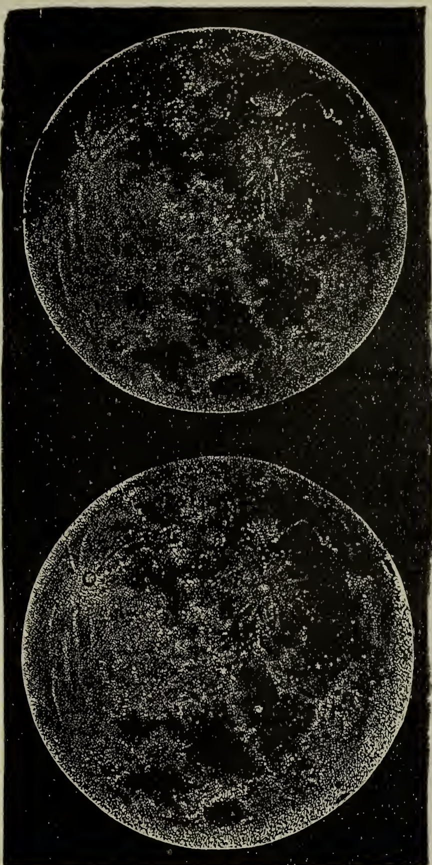


Fig. 74.—Stereoscopic Photograph of the Moon (Rutherford).

It is convenient to fix prints of this sort on to a series of cards joined together by hinges of cloth, so that they will fold up like a screen (fig. 75). The first print is fixed on 1, the second on 2, etc., so that they can be passed through the stereoscope from one end to the other, each print being right and left in turn according as it is coupled with the one preceding or the one following. At the end the first print must be repeated.

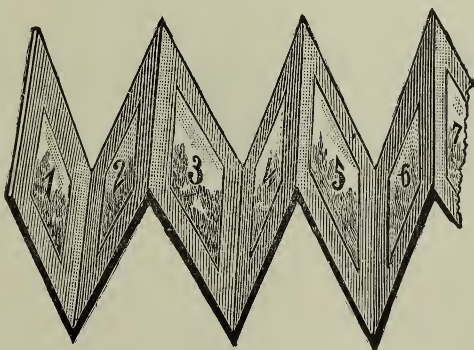


Fig. 75.

It is necessary to work with a plain background. If the background has any details they are seen without relief and the effect is not satisfactory. If the whole be of such small dimensions, that the background may be turned at the same time a better effect is obtained.

The fault of this method is that the light on the subject is not exactly the same during the two exposures, since the displacement is made in

reference to the direction of the light. But the differences resulting from it are very small, and it is necessary to look very closely to discover them.

Instead of moving the object by turning it on its own axis, it can be displaced—but only if a plain background be used—parallel to itself, and

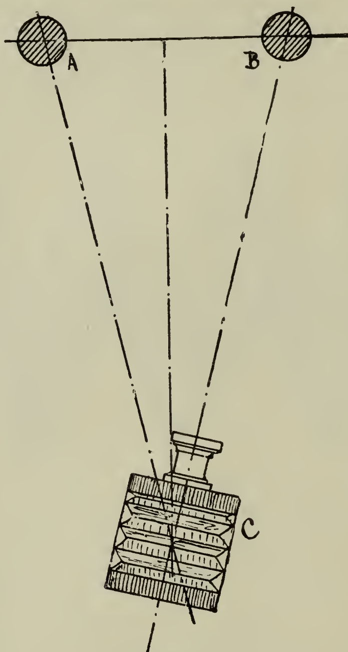


Fig. 76.

the camera slightly turned (without displacing it). The distance A B of the two positions of the object will be the same as would be that between the two positions, if the camera were moved.

This method, by displacing the object, is almost exclusively employed in stereoscopic photography, when medium or strong magnifying is in question. The object is fixed on to a *stereoscopic lever.** This is an instrument for holding the object mounted between two fixed points (fig. 77), whose axis passes through its centre, and which permits the object to be turned at a very small angle, to the right or left of the optical

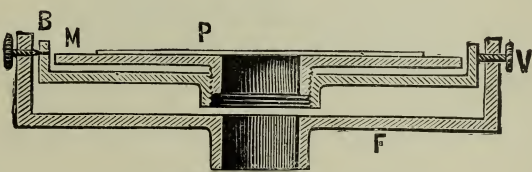


Fig. 77.

angle. This displacement is limited by two screws with ends.

After having mounted the object on the lever (where it is held by supports or springs) it is focussed and its position rectified till the middle of the subject is in accordance with the optical angle.

By means of wedges or of regulating screws, the height of the object may also be varied, so that the axis of rotation is in accordance with the

* W. Seibert has also obtained good stereoscopic photomicrographs by the *lateral* displacement of the object.

middle of the object. This regulation is necessary, because the plates which hold the object are not always of the same thickness.

The angle to be given between the two positions of the levers cannot be calculated exactly, because of the uncertainty of the depth of the object, its distance from the lens, etc. It is also much better to find this out experimentally.

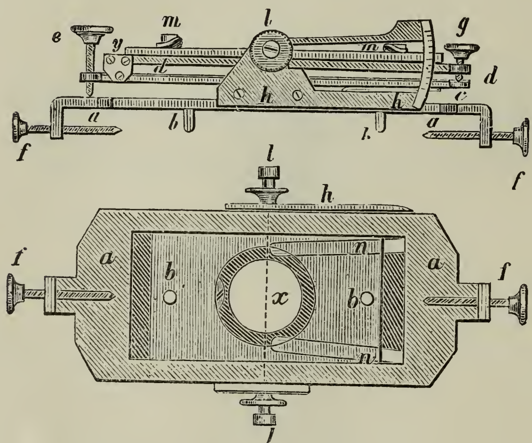


Fig. 78.

Meitessier (1866) suggested the angle of 12 degrees for lenses of low power (Nachet's No. 0), and 4 to 5 degrees for more powerful ones (No. 5).

The operation is the same as in ordinary photomicrography, care being taken to verify, and, if necessary, to rectify the focussing between the two exposures.

Fig. 77 represents an ordinary stereoscopic lever. Object P is fixed on the plate M, which is screwed on to the lever proper, B. By screwing this plate more or less, the height of the object is regulated. The screw F of the lever terminates in a socket, which fits into the object-holder of an ordinary microscope.

Fig. 78 shows the side and underpart of Fritsch's lever.

It is constructed as follows: *a* is the object-holder, on which the object is fixed by means of blocks *m*. This object-holder is movable round an axis *y* mounted at one of its extremities and resting on the lever proper *c*. The displacement round this axis controlled by the screw *g*, serves to regulate exactly the height of the object. The lever *c* is movable round the axis *x*, by the aid of a screw *e*, and the angular displacement is measured on a divided dial *h*. The screw-holder *a* can be displaced parallel to itself by the aid of the screws *f f*, for the regulation of the position of the object before the camera. For this it is mounted on a guide *b*, fixed by two claws on the plate of the microscope.

STEREOSCOPIC PHOTOGRAPHY BY SUCCESSIVE EXPOSURES.

THIS method, by which one plate is exposed first, and then after moving the camera, a second of the same view, is not generally recommended, because of the following disadvantages:

1st. The lighting of the subject may vary between the two exposures, but even if not, the times of exposure may not always be exactly measured;

2nd. In the case of a landscape lighted by the sun, the position of the shadows alters between the two exposures, and on the print the shadows often have the effect of black screens suspended in the air;

3rd. This method should only be applied to immovable objects; it is not as convenient for a portrait.

On the other hand, it permits the amateur photographer to work with his ordinary appliances, and produces a sensible reduction in cost of apparatus, as a special tripod top can be purchased—admitting of moving the camera—for a few shillings.

Let us suppose that O is the subject to be photographed; the separation G D of the positions must first be determined; then, in the case of a landscape, the camera must be placed successively at C C', to make sure that all is

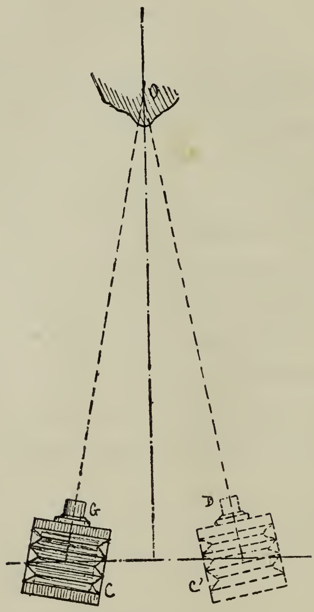


Fig. 79.

satisfactory. (If this precaution be neglected, it sometimes happens that, after one plate has been taken, a branch of a tree is found in the way of the second.) The two plates are then taken, after carefully ascertaining when focussing, that

the same parts of the landscape are within range. This operation is facilitated by tracing two diagonal lines on the ground glass, and focussing each time the same object at the crossing point. A camera furnished with a level is the best to use.

The camera in the two cases should be, as far as possible, at the same height.

There are two ways of proceeding: when the positions are very near, the stereoscopic plane-table may be used, and the stand of the camera need not be moved. But when, on the contrary,

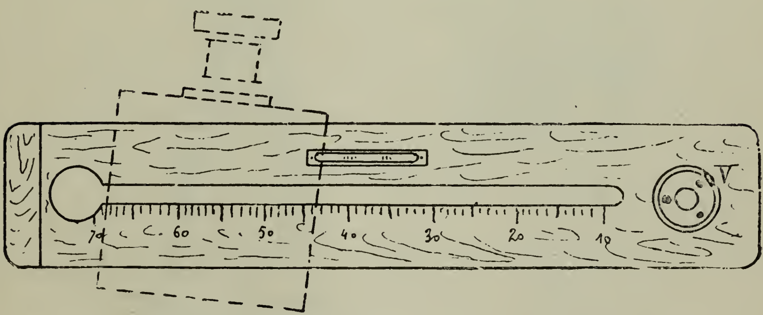


Fig. 80.

the distance between the positions is great, the apparatus must be mounted ordinarily on the stand, and the whole may be moved.

The stereoscopic plane-table (fig. 80) is a sort of divided ruler, fixed by V on the stand of the camera, and having in its whole length, a groove in which the screw which fixes the camera can

slide. The divisions on the table permit the camera to be placed at the desired distance.

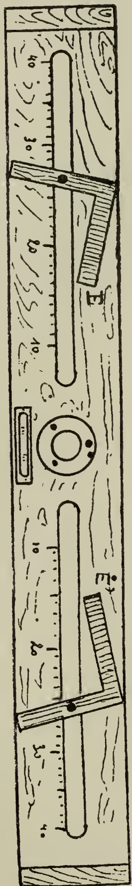


Fig. 81.

When a plate has been taken, the table must be turned 180 degrees, and the second taken in the same way, by turning the camera on its own axis.

For convenience of carrying, the table is generally of the same length as the folded stand. The two views can therefore be taken at a separation a little less than twice this length.

Often, too, the stereoscopic table is so fixed, that the camera may be mounted at each end without the table being moved (fig. 81).

This method has also the advantage of allowing an easier regulation of the two positions of the camera. This regulation is effected by two set squares E E', against which the cameras are fixed. The two positions of the camera can thus, before operating be exactly determined, and easily found again during the operation, as the squares remain in their places, when the

camera is removed. By this method the separation of the cameras can only be fixed at a length a little less than that of the table itself.

If the separation of the two positions exceeds that distance, the camera is mounted on the stand in the ordinary way, a plumb-line being suspended between the legs. This serves to regulate the positions and to measure the separation (fig. 82).

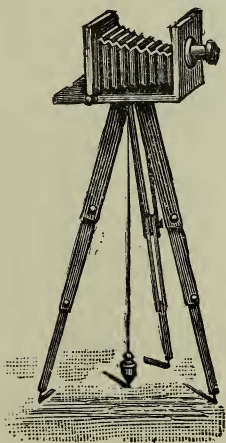


Fig. 82.

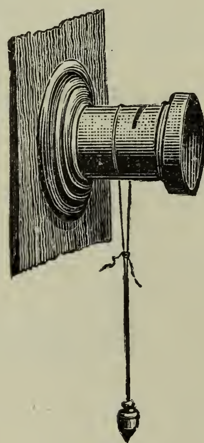


Fig. 83.

It is better still, if possible, to suspend the line from the lens. The cord should be tied in a slip-knot, which rapidly adapts the length to the height chosen (fig. 83).

In default of a plumb-line, any object (a small stone, for instance) previously placed on the

top of the lens, may be let fall. The place where it falls serves as a regulation point.

Care must be taken to give exactly the same exposure to each plate.

An intermediate method between this and the following, consists in employing a camera, in which the lens is movable horizontally. After marking the ground glass as in fig. 84, the lens is moved to the right, and the left of the range is covered by a card placed in the case behind the dark slide; that done, the first (right) exposure is

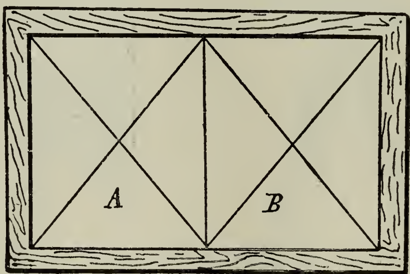


Fig. 84.

made on half the plate; the frame is then raised and the card put to the right, and the left portion exposed in the same way. It is evident that this method is limited in its application, since the maximum separation at which it can be fixed, is only that of the two extreme positions of the lens; it is even less because each time the camera is turned slightly the subject must be focussed to the centre of half the plate.

We have, however, found it very useful for photo-micrography with magnifying objectives of low power.

M. Moitessier (1866) invented, also for photo-micrography, an interesting way of taking two plates without changing the position of either the camera or the object.

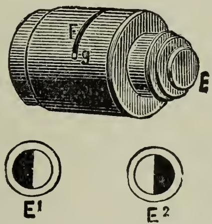


Fig. 85.

For this purpose, he uses successively the two halves of the surface of the lens.

The lens used has half its surface covered, and it is mounted by friction, in a tube in which it can be turned half-way round (fig. 85).

A notch F to which a pin *g* is fixed, regulates exactly the rotation.

STEREOSCOPIC PHOTOGRAPHY BY SIMULTANEOUS EXPOSURES.

THE most rational method of stereoscopic photography, is that by which two plates can be taken *at the same moment.* It is, moreover, the only one by which instantaneous work can be done; and it also offers advantages in cases where the subject is in repose, as it makes the taking of the two plates by the same light, a certainty.

In accordance with what we have already said, the separation of the lenses ought to vary with reference to the distance and depth of the subject, *if the maximum relief be desired.* Therefore, for the realisation of this condition, two separate cameras, movable in accordance with each other should be used.

But for various reasons, most photographers prefer to work with cameras of a fixed separation. The two instruments are then mounted together, and the operation does not differ materially from the taking of an ordinary plate. It is obvious that the relief must suffer from it, especially when

the foreground is absent. Stereoscopic cameras of fixed separation should therefore be judiciously employed. Their use is recommended for the studio; they are also useful for detectives, or for hand instruments; and give very satisfactory pictures of a landscape, when there is a foreground at a short distance; but they should not be used for distant subjects (panoramas, bird's eye views, etc.

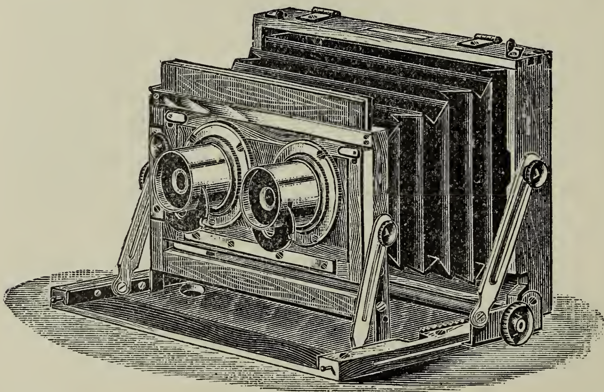


Fig. 86.

INSTRUMENTS OF FIXED SEPARATION.—These consist of a camera carrying two lenses as much alike as possible. The camera is divided into two by a screen, so that it makes two separate instruments, but each giving their pictures on one plate. Stereoscopic negatives are either made on half-plates or on the standard stereoscopic size, which is $6\frac{3}{4} \times 3\frac{1}{4}$.

The lenses are mounted ordinarily at the centres of each half of the plate.

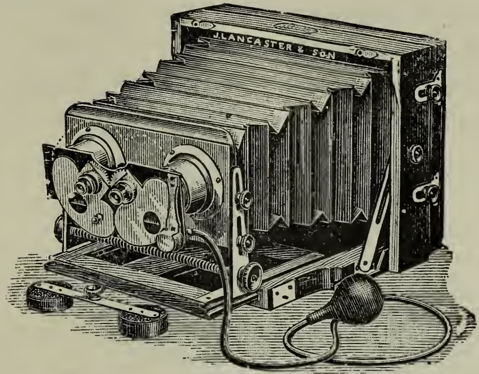


Fig. 87.

The English manufacturers have lately given considerable attention to the manufacture of

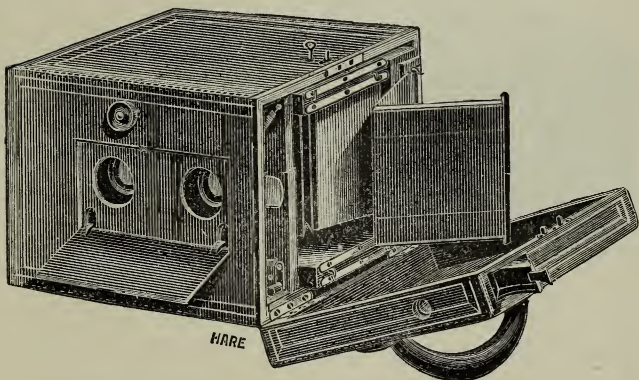


Fig. 88.

stereoscopic cameras, and many excellent instruments can now be obtained. We are only able

to illustrate and briefly allude to the principal makes.

Fig. 86 shows a stereoscopic camera of the ordinary kind, by Underwood. Fig. 87 shows Lancaster's Instantograph camera, fitted with

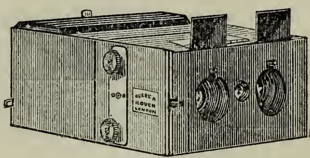


Fig. 89.

shutter. Fig. 88 illustrates Beck's Stereoscopic Hand Camera which holds six plates. In Fig. 89 is shown Rouch's Hand Camera, which is fitted with a patent changing back, admitting of twelve

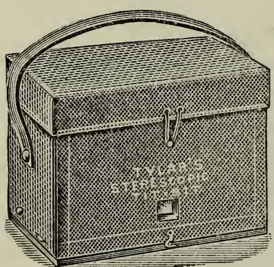


Fig. 90.

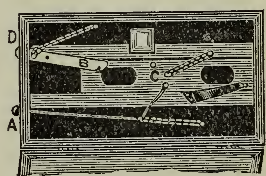


Fig. 91.

successive exposures. The Eastman Co.'s Nos. 5 and 6 Folding Kodaks are made for stereoscopic as well as for single pictures. Tylar's "Tit Bit" Stereoscopic Camera (figs. 90 and 91) is a very light hand instrument, weighing only two pounds.

Lizar's "Challenge" Stereoscopic Camera (fig. 92), but recently introduced, is very light and portable, and has an ingenious arrangement to obviate the use of a focussing cloth.

In all stereoscopic cameras, the two caps should be made to work together, and to open and

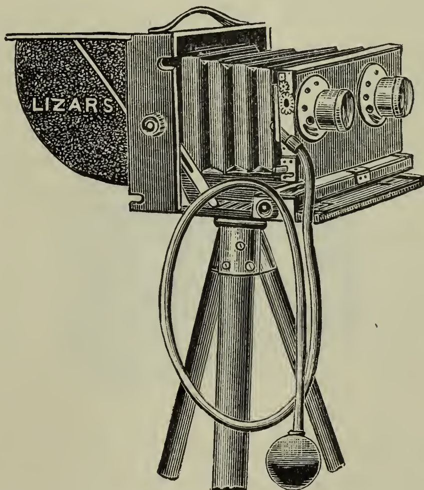


Fig. 92.

shut at the same instant, or a double shutter should be used.

One of the best stereoscopic shutters is the Thornton-Pickard (fig. 93). It is made to fit on the lens hoods, or in another form to work behind the lenses, so that it may be screwed to the camera front, and the lenses mounted on the front

of the shutter. The shutter has a detachable front panel, so that the pair of lenses may be removed and changed for another pair, or a panel carrying one of the lenses in the centre can be substituted for taking full sized pictures with the same camera. This panel can also be made with adjustable centres, so that the lenses may be separated to various distances.

The idea of the binocular camera seems to have originated with Brewster (1849), who also

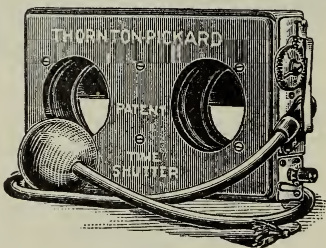


Fig. 93.

proposed to obtain lenses exactly alike, by cutting in two an ordinary lens. This idea has never, however, been adopted: in fact, it is of advantage to keep all the luminous powers of the lenses, and there is no difficulty in procuring them so accurately paired that the eye can perceive no difference in the focussing. Further, if there be a slight difference, it does not interfere with the perception of relief; a difference of $\frac{1}{50}$ passes unperceived.

Apparatus of Variable Separation.—These are the only cameras which correspond to all the needs of a stereoscopic photographer.

They consist of two separate compartments mounted on a stereoscopic plane-table, divided into demicentimétres.

The most convenient size for the dark compartments is about $3\frac{1}{2} \times 3\frac{1}{8}$ inches; however, as plates or films of this size are not easily procured, the size $4\frac{1}{4} \times 3\frac{1}{4}$ is more frequently chosen, though it is rather more cumbrous; on the other hand it does not require the same care in focussing the subject on the ground glass.

The form of the dark compartment matters little: any camera which can be bought will serve. The lenses should be movable vertically; the horizontal movement would be useless. The shutters should be worked by the same ball, by means of a T shaped pneumatic tube.

A great many kinds of stereoscopic cameras of fixed separation may be bought; but, as a rule, the photographer is obliged to make his own apparatus of variable separation.

We hope the figure representing the apparatus used by us, will be of service to our readers. The two cameras may be mounted either above or below the plane-table. We prefer the latter when the separation will allow it, because on one hand, the divisions of the table (which are above)

are entirely uncovered; and on the other, the frames are thus reversed, presenting the shutter side to the ground where the light can most easily get in. The lenses are furnished with pneumatic shutters, serving for either instantaneous or prolonged exposures. At each extremity of the table is a

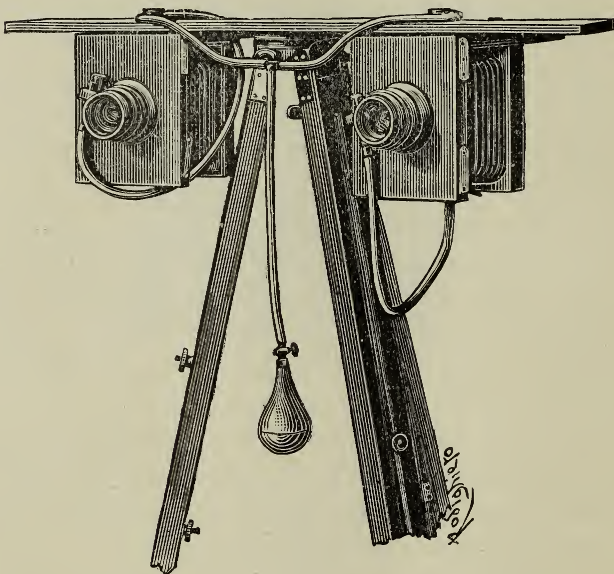


Fig. 94.

hole large enough to allow the insertion of the button which fixes the camera. It is only necessary, therefore to unloose the button by a turn, in order to remove the camera.

All the slides should fit either of the dark compartments. When the number of slides is uneven, care must be taken to alternate at the beginning two of the slides with a third, otherwise for the last exposure, two glasses would be left in one slide. For example, if there be three slides with plates numbered 1—2, 3—4, 5—6, the first exposure must be made with 1 and 3, the second with 2 and 5, and the last with 4 and 6.

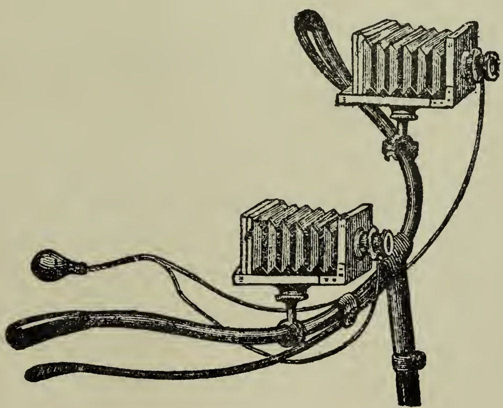


Fig. 95.

We must mention one variety of stereoscopic plane-table which would be useful to cyclists; it consists simply of fixing two dark compartments to the handle of a bicycle (fig 95).

The ordinary stereoscopic plane-tables are fitted with a level; it is, in fact, necessary that the optical centres of the two lenses should be on

the same horizontal plane. At the same time, it is not necessary to be very precise, and the table may even be levelled by sight. It is obvious that if its length be horizontally level, it is not necessary for its width to be so also. Therefore, very high objects* may be photographed without inconvenience, or, on the other hand, views may be taken from a height by inclining the apparatus accordingly. The picture will evidently cease to be rectilinear. But its distortion becomes perfectly admissible if, in examining the prints, the stereoscope be inclined in the same way, in which the camera was inclined.

* Bulletin of the Photographic Society of the North of France, 1889, p. 53.

STEREOSCOPIC PHOTOGRAPHY WITHOUT LENSES.

IN 1881, M. F. Méheux, by reproducing Porta's camera, in which the picture is obtained simply by a pin hole, succeeded in gaining remarkable photographic pictures, with detail sufficient for certain applications.

This process was followed by M. Colson, who by making the diameter of the hole in accordance with its distance from the plate, has succeeded in obtaining the maximum detail.*

M. Méheux from the first expatiated on the advantages of this plan; on the one hand, showing the absolute rectitude of the picture ; and on the other, the possibility of varying the focus within certain limits.

The process is also valuable in stereoscopic photography, the pictures obtained possessing perfect relief. An examination of figure 99, the reproduction of a stereograph in half-tone, gives assurance of this.

---

* R. Colson. *La Photographie sans objectif.*

By the aid of a stenope, an instrument illustrated in figures 96, 97 and 98, simple or stereoscopic views may be obtained as desired. The stenope is a disc, which is fixed on the camera in the place of the lens; it is pierced by two series of holes, the two at the extremity of the same diameter being equal. Under this disc, which is movable round its centre, three larger holes are pierced, whose positions are indicated by the three lines traced on the margin.

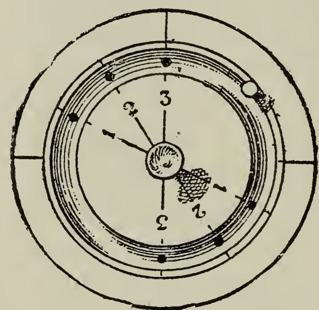


Fig. 96.—
Position for ordinary views.

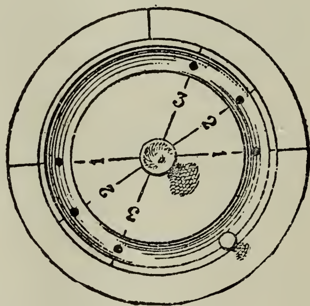


Fig. 97.—
Position for stereoscopic views.

If the plate be turned, as shown in Fig. 96, *i.e.*, if one of the lower holes be placed opposite one of the upper ones, the instrument gives a single picture; if on the contrary, it be turned as in Fig. 97, two of the lower holes will face the two side upper holes, and by dividing the compartment, a stereoscopic negative may be obtained.

For pin-hole stereoscopic work the diameter of the hole should be from 20 to $\frac{25}{100}$ of a millimétre, and its distance from the plate from 5 to 10 centimétres. M. Méheux, who gave us this information, pierces the holes with a bodkin in a

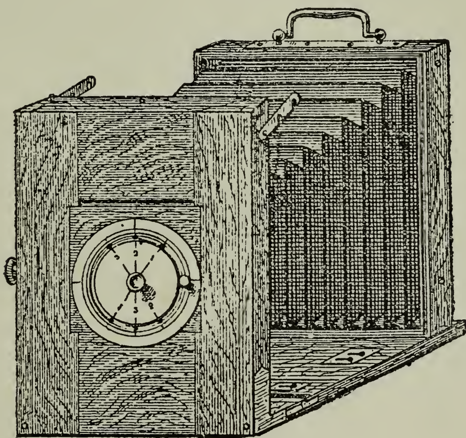


Fig. 98.

ferrotype plate or sheet of ebonite, so as to obtain a conical opening with sharp edges and without flutings.

Openings *stamped* in the plate are very unsatisfactory, because of the reflections produced by the edges of even very thin plates.

Fig. 99.—Stereoscopic Picture taken without Lens.

STEREOSCOPIC PHOTOGRAPHY BY ARTIFICIAL LIGHT.

WE have already insisted on the importance of obtaining the two halves of the stereoscopic negative in conditions as nearly identical as possible, from the photographic point of view; in other words, they should be taken at the same moment, and with the same length of exposure. There is, however, little difficulty in doing this ordinarily. But *absolute* simultaneity may be realised by the process of lighting the subject only during the time necessary for the exposure.

This is only practicable by the use of an artificial light.

The object O (fig. 100) must be focussed in the two cameras c c', and the two lenses be opened. The exposure is then made by means of a magnesium light; if the face has to be lighted, this light must be placed at E. It is evident that under these conditions, the two plates receive the same light at the same moment.

Fig. 101 is a reproduction in half-tone of a stereograph thus obtained.

We do not think it necessary to describe in detail the processes of lighting the sitter, and prefer to refer our readers to special treatises. All the sources of light employed by the ordinary photographer, may be also used in this case.

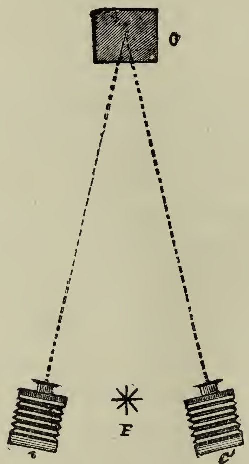


Fig. 100.

Magnesium being generally used, we will, however, remark that the instruments in which a metallic powder is blown into a flame, cannot be used for instantaneous work, though they are the most convenient arrangements for ordinary exposures. The result of Dr. Eder's experiments demonstrates the fact that magnesium light thus

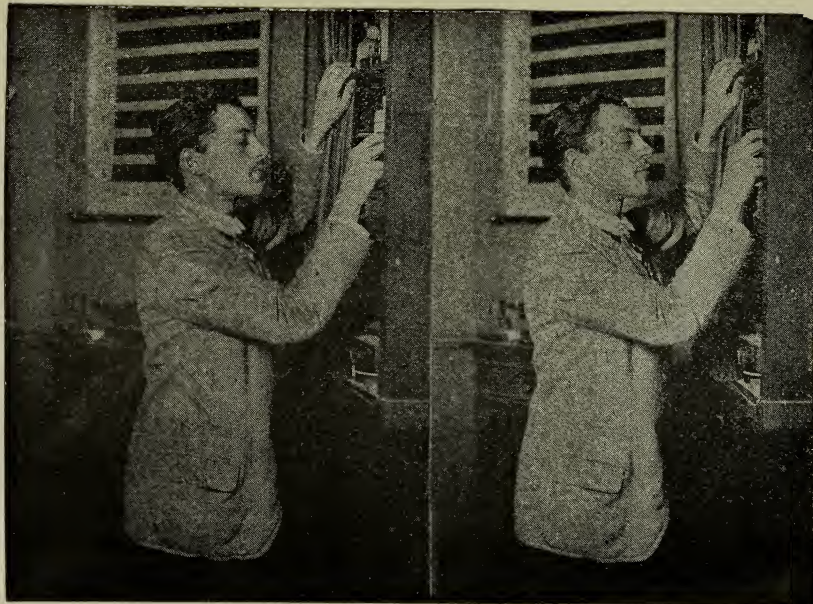


Fig. 101.

produced has at least a duration of a third or a quarter of a second; whilst special mixtures (in which magnesium is mixed with a combustible such as chlorate of potash) have for their duration only $\frac{1}{80}$ part of a second.

In spite of the precautions necessary in the manipulation of these mixtures, we must always give them the preference when it is necessary to reduce to a minimum the time of exposure.

STEREOSCOPIC NEGATIVES.

WE do not intend here to describe the details of photographic manipulation. Our book is addressed to photographers, who are already familiar with these operations. We will merely give formulæ in ordinary use. One recommendation may prove useful: if the stereo-negative is on two plates, always treat both of them at the same time, develop them in the same bath, and intensify or reduce them together, etc.

FERROUS OXALATE DEVELOPMENT.

A.

Water	32 ounces
Potassium Oxalate	75 drachms
Potassium Bromide	15 grains

B.

Water	16 ounces
Iron Sulphate	50 drachms
Sulphuric Acid	A few drops

For use mix of:—

Solution A	4 parts
Solution B	1 part

Pour B into A, and not A into B.

* * *

PYRO AND AMMONIA.

A.

Water	32 ounces
Potassium Bromide	2½ drachms
Ammonia	4¼ ,,

B.

Water	6¼ ounces
Pyro	30 grains

Equal parts of each.

***

PYRO AND SODA.

A.

Water	32 ounces
Sodium Sulphite	6 drachms
Sodium Carbonate	6 ,,

To make developer add pyrogallic acid to the above solution in the proportion of 50 or 60 grains to each bath of 32 ounces.

***

HYDROQUINONE.

Water	16 ounces
Sodium Sulphite	6 drachms
Hydroquinone	92 grains
Sodium Carbonate	5 drachms

***

EIKONOGEN.

Water	18 ounces
Sodium Sulphite	25 drachms
Eikonogen	5 ,,
Potassium Carbonate	10 ,,

***

HYDROQUINONE AND EIKONOGEN.

Water	48 ounces
Hydroquinone	108 grains
Eikonogen	185 ,,
Sodium Sulphite	$38\frac{1}{2}$ drachms
Potassium Carbonate	19 ,,

*
* *

AMIDOL.

Water	32 ounces
Sodium Sulphite	12 drachms
Amidol	77 grains

*
* *

METOL.

Water	10 ounces
Sodium Sulphite	$25\frac{1}{2}$ drachms
Metol	154 grains
Solution Soda Carbonate, 30%	10 ounces

*
* *

FIXING SOLUTION.

Water	$3\frac{1}{4}$ ounces
Hyposulphite of Soda	$5\frac{1}{4}$ drachms

*
* *

INTENSIFICATION.

1.

Water	$3\frac{1}{4}$ ounces
Mercury Bichloride	30 drachms

2.

Water	$3\frac{1}{4}$ ounces
Ammonia	$2\frac{1}{4}$ drachms

Avoid over-development, as hard prints produce even stronger contrasts under the stereoscope than when viewed in the ordinary way. The curious effect of "snow," seen in many stereoscopic views, arises from lack of uniformity in the development of the negatives.

STEREOSCOPIC POSITIVES.

STEREOGRAPHS.

STEREOSCOPIC positives may be printed on paper or on glass. As before, we will leave the details of manipulation, and content ourselves with recalling the formulæ.

There is a great variety of sensitized papers upon which prints may be made, such as albumenized, salted, ferro-prussiate, platinum, the various gelatine papers (aristotype, citrate of silver, etc.), and lastly, gelatino-bromide papers.

For transparencies, either ordinary gelatino-bromide plates, or plates prepared specially for positives (gelatine-chloride, etc.), may be used. But, in preference, we advise the use of *dry collodion*, which gives transparencies more delicate and of a more agreeable tone.

TONING SOLUTION.

Water	32 ounces
Sodium Acetate	$7\frac{1}{4}$ drachms
Gold Chloride	15 grains

***

M

FIXING SOLUTION.

Water	32 ounces
Hyposulphite of Soda	7½ drachms

*
* *

TONING AND FIXING FOR ARISTOTYPE.

Water	25½ ounces
Hyposulphite of Soda	6½ ,,
Ammonium Sulphocyanide	5 drachms
Sodium Acetate	4 ,,
Solution of Saturated Alum	14 ,,

Put into the bottle a few paper clippings or a little chloride of silver to saturate the bath. In three or four days filter and add :—

Water	6¼ ounces
Gold Chloride	15 grains
Ammonium Chloride	30 ,,

*
* *

COMBINED TONING AND FIXING BATH.

A.

Water	17 ounces
Sodium Hyposulphite	6¼ ,,
Ammonium Sulphocyanide	6½ drachms
Alum	7½ ,,
Solution of Acetate of Lead	1½ ounces

Filter when cold.

B.

Distilled Water	3 ounces
Gold Chloride	15 grains

The bath is formed of:—

Water	3½ ounces
Solution A	3½ ,,
Solution B	2¼ drachms

***

TRANSPARENT POSITIVES GELATINO-BROMIDE.

A.

Amidol	2¼ drachms
Potassium Metabisulphite	15¼ ,,
Water	2½ ,,
Solution A	4¼ drachms
Water	22 ,,
Solution of Potassium Carbonate 10%	2 ,,
,, Ammon. Bromide %	8 ,,

***

DEVELOPER FOR GELATINO-CHLORIDE TRANSPARENCIES.

Water	21 ounces
Sodium Sulphite	1 ,,
Amidol.........................	1 drachm

When the two plates are separate it is convenient to put them near together on one glass, taking care, in order to avoid a space between the two prints, to cut from the right of one plate and the left of the other, all that part which extends beyond the print itself. The two plates are then fixed together with bands of gummed paper, after being put at exactly the same height. The positions may be tested by printing a trial proof,

and looking at it in the stereoscope. The whole of the double glass must then be enclosed in a frame, which masking the print will serve to regulate the cutting of it.

When the printing is less important, it is sufficient to place the plates side by side in one frame. Thus the two proofs are printed on the same sheet of paper, which makes it sure that both proofs will be subsequently operated on at the same time. They are afterwards cut apart and mounted on the same card.

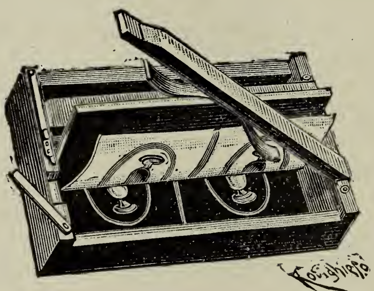


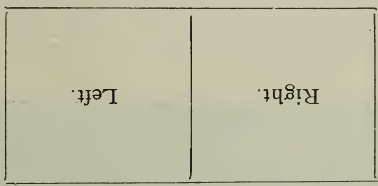
Fig. 102.

The size of stereoscopic cards is $6\frac{1}{2} \times 3\frac{1}{4}$.

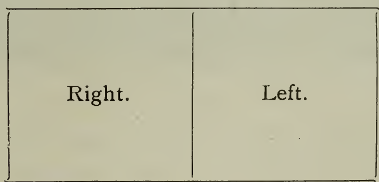
When the negatives are on separate plates it is better to put the two plates in the frame, with the tops at opposite ends, so that in opening only one of the sides, the lower part of one of the prints and the upper part of the other are seen.

For this purpose, a frame opening across its width (fig. 102) is very useful. If negatives

obtained with a binocular camera have to be dealt with, they can be cut for operating as before; but it is better to keep them together, and so print the positives directly for subsequent cutting and to transpose them. This transposition is necessary, for the double picture seen on the ground glass presents itself as under :—



The positive will therefore be seen in the same way, and after turning them right side up, they will be :—



so that it is necessary to transpose the prints.

In order to avoid this transposition, the use of a paper twice the length of the plate has been suggested; it should be folded as shown in Fig. 103. The negative is first placed on the part A B, then on the part C D; afterwards the paper is cut across M M' and two prints are obtained

showing the pictures in their true positions. Another method is to cover half the plate and print the proofs successively so that they may be put at the proper sides; but all these methods do not appear of great value to us; in fact, great care has to be taken to put the prints exactly in place, and also the two halves of the stereograph being printed at different times, stand a great chance of not being equally dense. This is only of

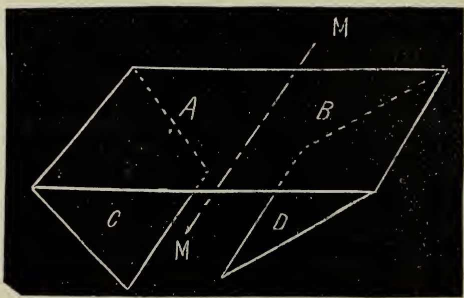


Fig. 103.

importance as regards the general aspect of the prints, as the stereoscopic effect does not suffer.

The printing of transparent positives by contact can be done on a single glass, when the two plates have been placed sufficiently near together. In other cases, the two positives are printed separately, and are fixed together on one glass, which serves at the same time to protect them. It is better to use very thin glasses for

both the positive and the covering, so that the thickness of both together does not exceed two millimètres.

For the positive printed by contact to be seen correctly, the film side must be looked at; therefore the glass which covers it must not be flashed. This is no inconvenience, as many stereoscopes are already fitted with flashed glass. It would also be easy to remedy it by placing a piece of flashed glass in the stereoscope with each transparency.

To replace this dull glass, the grain of which is often disagreeable, Woodbury proposed to cover the stereoscopic positive with an emulsion of zinc oxide in gelatine.

Transparencies may be printed on the same glass, even from plates obtained by binocular cameras, by taking them at two separate exposures, or better still by using a copying camera.

To work by contact by two separate exposures, a special frame is used (fig. 104), which is half as long again as the binocular negative; the opening part of the surface is only the size of a single picture. The negative being placed D G on the left end of the frame. The plate is placed at P; it is then exposed to the light for an impression of the right picture to be made. The negative is then moved to the right, and the glass to the left, for the left impression to be made. The opening

part of the frame is covered by a shutter V, which is opened for arranging the position.

It is not an absolute necessity to have a special frame for this operation. M. A. Buguet has fixed in an ordinary frame a sheet of black paper, which brings about the same result.

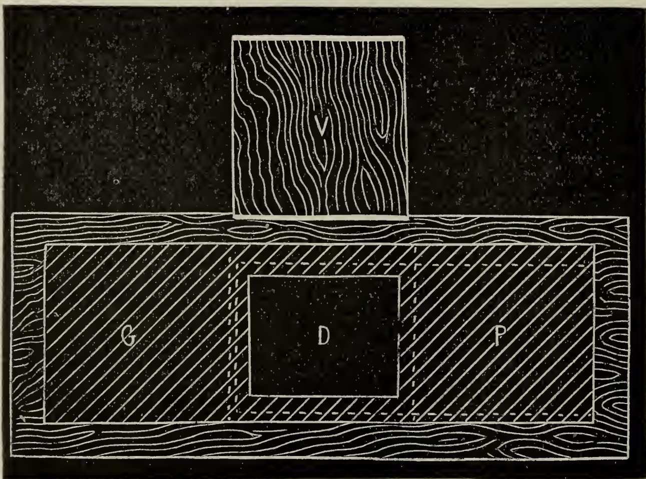


Fig. 104.

In mounting transparencies it is better to introduce between the two glasses a mask of black paper, which marks clearly the picture and improves the general aspect, by hiding the irregularities always present at the edges of the glass.

To obtain a print from a binocular negative with the copying camera, the negative is placed before a stereoscopic camera of long focus. This camera has two lenses, and is also furnished with an interior partition; this partition may be fixed outside if desired, between the two lenses and the negative.

The two positives obtained, seen as in nature, will be in their proper places, the left picture to the left and the right one to the right. The positive may be looked at either from the glass or the film side, according as the face or back has been turned to the camera.

M. Donnadieu has specially invented for this application, a camera with two compartments, by which the work is more easily done. The part which receives the negative is formed of two bellows, prolonged by a partitioned box. The plate holder is movable so that an exact centre may be found.

Stereoscopic positives may be coloured: we always find, however, that they lose their exactitude very perceptibly after colouring, because it is very difficult to limit the colour properly. This is particularly noticeable in the foreground. It is well-known that all deformation of the contours tends to falsify the relief. All the sunken parts, the masses of verdure, the details which have such a pretty effect in the stereoscope, lose their

delicacy. Therefore it is better to use only very light tints and with all possible precision.

The same remarks also apply to transparent positives, which can be coloured in the same way. M. L. Vidal advises the use of transparent aniline colours, diluted with a rather thick varnish, having a basis of gum-lac. The painting is done on a retouching desk. Care must be taken not to breathe on the transparency, or it will take an opal tint: this can be remedied, however, by warming it.

All the processes of photo-mechanical impressions, either sunk or in relief, may be used for the rapid printing of stereoscopic pictures. Half-tone constitutes an excellent means of stereoscopic illustration, as figures may be introduced into the text. We have, moreover, made use of it in this book. Photogravure appears to us the most perfect means of obtaining at a cheap rate, collections of artistically valuable stereoscopic pictures.

A FEW WORDS OF HISTORY.

IN the preceding chapters we have mentioned, as far as possible with the dates of invention, the various improvements pertaining to the stereoscope or to stereoscopic work. To complete this account, we propose to review the principal ideas having connection with binocular vision, held before Wheatstone, by inventing the first stereoscope, gave material proof of their exactitude.

It was long a well-known fact that the two eyes saw with a different perspective the same object placed at a short distance.

Leonardo de Vinci in *Trattata della Pictura Scultura ed Architettura*, Milan, 1584) remarked that the two pictures furnished by the eyes, intercepted on the background two different parts; and also added, that this was the reason why no painting could have a *relief*, equal to that given by a direct view, if the object be not placed at too great a distance.

According to the researches of Brewster, J. B. Porta gave, in 1593, a drawing so complete of the two pictures, as seen by the two eyes, that not only the principle, but the construction of the stereoscope also is readily recognised. At the same time there is no proof that before Wheatstone,* anyone ever drew right and left pictures.

In 1613, the Jesuit, Aguilonius, in his essay on Optics, also advocated the idea that pictures seen by the two eyes were different.

In 1775, Harris plainly said that there were no other means of distinguishing relief but those by which we distinguish distance, light or shade, and that owing to the separation of the eyes, we can see the two sides of an object placed

---

* In 1859, Messrs. A. Crum Brown and John Brown, visiting the Wicar Museum at Lille, noticed two drawings, one by the pen and the other in water colours (Nos. 215, 216), representing a young man seated on a bank, the work of Jacopo Chimenti da Empoli, painter of the Florentine School (1554-1640). Brewster was of opinion that these two pictures, taken from two rather different points of view might be united stereoscopically, so as to give a picture in relief. But Mr. Bingham presented to the French Photographic Society, a short time after this observation, photographic reproductions of these drawings. It was found that superposition could be produced, but that there was no relief.

sufficiently near, and smaller than that separation; so that a certain amount of relief is the result.

Mayo was the first to plainly set forth in 1833 *(Outlines of Human Physiology)* the principle on which the stereoscope is based:—" A solid object, being so placed as to be regarded by both eyes, projects a different perspective figure on each retina; now if these two perspectives be actually copied on paper, and presented one to each eye, so as to fall on corresponding parts, the original solid figures will be apparently reproduced in such a manner, that no effort of the imagination can make it appear as a representation on a plane surface."

In the winter of 1832 he had his first stereoscopes made by Newman, but it was not till 1838 that he published his first account of the subject.

Contributions to the Physiology of Vision.

(Part I.—On some remarkable and hitherto unobserved phenomena of binocular vision.)

Philosophical Transactions, 1838. Pp. 371-394.
Annales de Chimie II., 1841. Pp. 330-370.
Poggendorf's Annalen LI., 1842. Pp. 1-48.
Part II.—Id.—
Philosophical Transactions, 1852. Pp. 1-18.

Philosophical Magazine III., 1852. Pp. 241-267, 04-523.

From 1845, Wheatstone used photographs for his stereoscope of reflection.

The subject was again taken up by Sir David Brewster, who has published a great many memoranda on the subject:

On the law of middle position in single and binocular vision, and on the representation of solid figures, by the union of dissimilar plan pictures on the retina (1843).

Transactions of the Royal Society of Edinburgh XV., 1844. Pp. 349-368.

Philosophical Magazine, XXIV., 1844. Pp. 356-365, 439-455.

On the knowledge of distance given by binocular vision.

Transactions of the Royal Society of Edinburgh, XV., 1848. Pp. 663-675.

Philosophical Magazine, XXX., 1847. Pp. 305-318.

An account of a new stereoscope.

Reports of the British Association for the Advance of Science, 1849. Pp. 6-7.

Description of several new and simple stereoscopes for exhibiting as solids one or more representations of the solid on a plane.

Transactions of the Royal Society of Arts, III., 1851. Pp. 247-258.

Philosophical Magazine, III., 1852. Pp. 16-26.*

It was in 1849 that Duboscq began to make stereoscopes with lenses, and binocular daguerreotypes, and delivered to the trade instruments which are still the most practical stereoscopes, and whose forms have only been modified in details.

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* *Memoranda on the modifications and improvements of the stereoscope*, by Sir David Brewster.

THE END.

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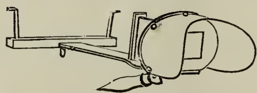

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